DISTRIBUTION AND MASS LOADING OF INSECTICIDES IN THE SAN JOAQUIN RIVER, CALIFORNIA

Spring 1991 and 1992

by

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PURPOSE AND BACKGROUND

Scientists from the Central Valley Regional Water Quality Control Board tested water quality in the San Joaquin River (SJR) watershed using toxicity tests. They found that water samples from certain areas of the watershed caused a species of water flea (*Ceriodaphnia dubia*) to die. *Ceriodaphnia dubia* is used in these toxicity tests because it is sensitive to insecticides and represents aquatic arthropods (one of the components of the U.S. Environmental Protection Agency three-species toxicity test). Based on these results, the Central Valley Regional Water Quality Control Board suggested pesticides as the possible cause. Before 1991, little work had been conducted to characterize insecticide concentrations and distributions in this watershed. Due to the need for more information concerning insecticide residues in the watershed, the Department of Pesticide Regulation (DPR) conducted a survey from 1991 to 1993, focusing on three seasons of high insecticide use: (1) winter dormant spray (report available), (2) spring, and (3) summer seasons (report in preparations). This report summarizes data collected during the spring season. The purpose of this project was to characterize insecticide concentrations and distributions in this watershed.

STUDY METHODS

DPR scientists sampled one site to establish patterns of water quality characteristics and insecticide concentrations during March and April of 1991 and 1992. They also sampled 17 other sites throughout the watershed to determine mass loading of insecticides in the watershed. Pesticide concentrations were measured using multi chemical analytical methods (called screens) that are capable of detecting many pesticides. Screens were used to test for three classes of chemicals–organophosphates, carbamates, and endosulfan.

RESULTS AND DISCUSSION

Nine of 19 pesticides were detected during the spring season. Diazinon, an organophosphate, was detected in 9 of 36 samples (25 percent) and endosulfan in 20 of 83 samples (24 percent). Diazinon is used as a dormant spray during winter months and is also used during spring months on alfalfa and for structural pest control. Endosulfan residues were attributed to use prior to January 1991, due to location of use relative to detections and its long persistence in soil. Carbofuran, a carbamate, was detected in 17 of 83 samples (20 percent); it is used predominantly on alfalfa during the spring. The carbamate oxamyl was detected in 9 of 83 samples (11 percent) and is used mostly on tomatoes in the southern part of the study area. The remaining five

insecticides (carbaryl, chlorpyrifos, dimethoate, malathion, and methidathion) that were detected occurred in less than 6 percent of the samples analyzed for these chemicals.

Salt Slough and the west-side tributaries contributed all the carbofuran, endosulfan, and oxamyl found in the SJR. In contrast, the east-side tributaries did not carry measurable loads of these insecticides in spite of their use in these basins. West-side soils are fine-grained and highly erodible compared to the coarse-grained, permeable soils of the east side. This difference in soils might explain these results, in part.

CONCLUSIONS

The U.S. Environmental Protection Agency has acute criteria for the protection of freshwater aquatic life for two of the insecticides detected in this study: chlorpyrifos and endosulfan. Each chemical had one detection above this criterion. Currently no restrictions exist on chlorpyrifos use; however, a voluntary effort to control chlorpyrifos residues during the dormant season is underway. Restrictions on endosulfan use were implemented in 1991 as a result of fish kills and detections in other watersheds in the state. Subsequently, detections in the SJR were below the acute criterion in 1992.

Through its Dormant Spray Water Quality Program, DPR seeks to prevent aquatic toxicity from insecticide residues in the Sacramento and San Joaquin Rivers. The initial effort focuses on promoting voluntary efforts to prevent aquatic toxicity, for example. Concurrently, monitoring data by DPR will verify compliance with water quality standards. DPR hopes that preventive actions taken by growers will prevent aquatic toxicity and forego the need to impose restrictions. DPR will evaluate the success of the voluntary efforts toward achieving water quality compliance using standard toxicity tests. DPR may impose regulatory measures, depending on the assessment of the monitoring results. As long as progress continues toward compliance with the water quality standard, regulations will be unnecessary.

ABSTRACT

From 1988-1991, scientists from the Central Valley Regional Water Quality Control Board (CVRWQCB) tested water quality in the San Joaquin River (SJR) watershed using bioassays. Results indicated water samples from certain regions of the watershed caused mortality to the water flea, *Ceriodaphnia dubia*, with insecticides implicated as the potential cause. Prior to 1991, little work had been conducted to characterize insecticide concentrations and distributions in this watershed. Therefore, to provide more information concerning insecticide residues in this watershed at that time, a survey was conducted from 1991-93, focusing on three seasons of high insecticide use: (1) winter dormant spray, (2) spring, and (3) summer seasons. This report summarizes the spring season. Additional reports cover the other two periods. The survey consisted of two components: (1) sampling at one site to establish the temporal pattern of water quality parameters and insecticide concentrations, and (2) spatially distributed sampling (Lagrangian surveys) to determine mass loading of insecticides in the watershed. Water samples were analyzed using three chemical screens: organophosphate, carbamate, and endosulfan. Nine of 19 pesticides were detected during the spring season. Diazinon was detected in 9 of 36 samples (25%) and endosulfan in 20 of 83 samples (24%). Diazinon is used as a dormant spray during winter months (January and February) and is also used during spring on alfalfa and for structural pest control. Endosulfan residues were attributed to use prior to January 1991, due to location of use relative to detections, and its long field half-life. Carbofuran was detected in 17 of 83 samples (20%), and is used predominantly on alfalfa during the spring. Oxamyl was detected in 9 of 83 samples (11%) and is used mostly on tomatoes in the southern portion of the study area. The remaining five insecticides; carbaryl, chlorpyrifos, dimethoate, malathion, and methidathion, were detected in less than 6% of the samples analyzed for these analytes. The U.S. EPA has acute criteria for the protection of freshwater aquatic life for two of the insecticides detected in this study, chlorpyrifos and endosulfan. Each chemical had one detection above this criterion. Lagrangian surveys were useful for identifying tributaries responsible for insecticide loading into the SJR. Salt Slough and the west-side tributaries contributed all the carbofuran, endosulfan, and oxamyl found in the SJR. In contrast, the east-side tributaries did not carry measurable loads of these insecticides in spite of their use in these basins. The fine-grained, highly erodible soils of the west side contrasted with the coarse-grained, permeable soils of the east side might partially explain these results. In addition, the physical and chemical properties of the insecticides aided in interpretation of detections. Therefore, although use patterns were helpful for interpreting insecticide patterns, they alone were not sufficient. Continued monitoring during spring months is recommended to determine if current use restrictions remain effective or new use restrictions are warranted.

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INTRODUCTION

The SJR flows through the northern portion of the San Joaquin Valley, an area of intensive agriculture. In counties with perennial SJR flow (Merced, San Joaquin and Stanislaus Counties), major crop acreages include alfalfa, almonds, beans, corn (silage), grapes, tomatoes, walnuts, and wheat. Over 300 pesticides were used in these three counties, with an annual reported usage of over 18 million lbs in 1992 (DPR 1993).

In spite of the high use of pesticides in this region, little work had been conducted to characterize their distribution in surface water prior to this study. The temporal distribution of pesticides had been monitored monthly by the U.S. Geological Survey (USGS) at one site on the SJR since 1988 (Anderson et al., 1990; MacCoy et al., 1995). This site is currently part of the USGS National Stream Quality Accounting Network. Pesticide concentrations were also measured once in 1985 at 32 additional sites in the basin (Shelton and Miller, 1988). Pesticides detected in water in these surveys include carbofuran, carbaryl, chlorpyrifos, DDT, diazinon, dieldrin, ethion, lindane, and ethyl and methyl parathion. More intensive spatial and temporal sampling, and pesticide mass-loading in the SJR watershed, had not been conducted at the time this study began.

In 1988, scientists from the Central Valley Regional Water Quality Control Board (CVRWQCB) began testing water quality in the San Joaquin River (SJR) watershed using bioassays. The purpose of these tests was to characterize water quality in the SJR, its tributaries and drains, and to identify sources of toxicity seen in bioassays (Connor, 1988). Results indicated waters from certain regions of the watershed caused mortality to the water flea, *Ceriodaphnia dubia* (Foe and Connor, 1991). The specific cause of toxicity was not determined but was attributed to pesticides in general.

Due to the reported toxicity of SJR water to *C. dubia* and the need for more information concerning spatial and temporal patterns of pesticide residues in the river, a two-year study was conducted from 1991-93. Analytical screens used for this study focused on insecticides since *C. dubia* is an aquatic invertebrate. Sampling was conducted in three seasons of high insecticide use: (i) the winter dormant spray season (December - February), (ii) the spring season (March - April), and (iii) the summer season (July - September) when a large variety of crops are grown. The objective of these studies is to document the spatial and temporal distribution of insecticides in the watershed during peak use seasons. This report contains data collected during two spring seasons: March and April of 1991and 1992. Two additional reports cover the remaining seasons. Study results will be used to identify regions and seasons of high contamination, and drainage basins contributing highest insecticide loads to the SJR.

MATERIALS AND METHODS

Study Area Hydrology

The San Joaquin Valley, approximately 12,000 mi^2, can be divided into two drainage basins, the San Joaquin and Tulare Basins (Fig. 1). The Tulare Basin is a closed basin: water drainage begins and ends within the basin boundaries. In addition, surface water streams are all ephemeral (Domagalski, 1995). In contrast, the San Joaquin Basin drains into the Sacramento-San Joaquin Bay Estuary, a valuable fishing and wildlife resource. The basin contains surface water streams and rivers, both ephemeral and perennial in nature. The SJR itself has perennial flow from Stevinson (site 1 in Table 1 and Fig. 1), northward about 64 river km to Vernalis (site 17), passing through Merced and Stanislaus Counties. Downstream of Vernalis, in San Joaquin County, tidal influence from the estuary begins. Sampling in this study was restricted to areas of perennial flow in the San Joaquin Basin due to its potential year-round contribution of pesticides to the estuary.

The SJR has three major tributaries on the east side of the valley: the Merced, Tuolumne, and Stanislaus Rivers, which originate in the Sierra Nevada Mountains (Fig. 1). In addition, there are a number of small irrigation district drains which carry excess irrigation water as well as agricultural runoff water from the valley floor to the San Joaquin River and these tributaries. Soils on the east side of the valley, which originate from the Sierra Nevada batholith, are generally coarse textured and well drained (Domagalski, 1995). On the west side of the valley, surface water streams are ephemeral and originate in the Coastal Range. These tributaries frequently carry rain and irrigation runoff from agricultural fields. Soils on the west side, which originate from the marine shales of the Coastal Range, are generally fine textured and highly erodible (Domagalski, 1995).

Sampling Plan

During March and April of 1991 and 1992, sampling was conducted about twice weekly in the San Joaquin River at Laird Park (site 12, Table 1, and Fig. 1). Sampling was conducted from March 4 through April 22, 1991, and March 2 through May 4, 1992. This site served as an indicator of the temporal variation in water quality parameters and insecticide concentrations occurring in the study area.

In addition to monitoring the temporal insecticide pattern, the mass loading of insecticides into the SJR was examined using a Lagrangian survey (Hanor, 1988; Meade and Stevens, 1990). This survey consists of sampling a single parcel of water as it moves down the SJR, capturing tributary inputs as they are timed to meet the main stem of the river. Sites sampled along the main stem of the SJR are timed (using velocity and distance to the next sampling point) so that the same parcel of water is sampled as it moves downstream. Therefore, if two sampling sites are measured along the main stem of the SJR and there are no tributary inputs between them,

the discharge should be equal at those two sites, given no major inputs from or losses to groundwater. In addition, insecticide concentrations (and mass) would be equal, given the same assumptions.

In this study, to maximize information about tributary contribution to mass loads of insecticides in the SJR, sampling sites on the main stem were located downstream from major tributaries. Water sampled in a tributary was timed such that the parcel in the tributary arrived in the SJR when the SJR site was to be sampled. For example, the SJR site at Stevinson (site 1) is located above the confluence of Salt Slough (site 2), and is the first sampling site in the study area. When water was sampled at Stevinson, the time required for that parcel of water to reach the next SJR site at Fremont Ford (site 18) was recorded. To determine when to sample Salt Slough, the distance between Fremont Ford and the confluence with Salt Slough was divided by the river velocity between those points to determine the amount of time it would take for the parcel of water to move between the two locations. This was added to the divisor of distance and velocity from the Salt Slough site to the confluence with the SJR to estimate what time to collect water from Salt Slough. Velocity data were either available from existing gaging stations or measured. If timed well, the discharge measured at Fremont Ford should equal, within about 10% (the variation associated with discharge measurements), the sum of the discharges from Stevinson and Salt Slough assuming no major losses or inputs to the system between these sites.

This sampling strategy enables source identification of insecticides to the river, either from a tributary or direct discharge to the main stem. Mass loads at each sampling location were determined by multiplying discharge by concentration to obtain lbs/hour. Tributary contributions can then simply be added to see if they match the amount of material found in the main stem of the SJR. If timed well, (as determined by summed discharge values within 10%), then mass loads within 30% (which also includes 20% variation associated with chemical analysis) indicate conservative transport in the river. More or less than the estimated variation allowance indicates sources or sinks for the insecticide between the sampling sites. Thus, this sampling strategy allows identification of regions of high insecticide contribution to the SJR watershed and could facilitate any mitigation strategies, should they be necessary.

The Lagrangian surveys were conducted in April in an attempt to examine springtime distributions separate from dormant spray insecticides. A total of three Lagrangian surveys were conducted during the weeks of April 2, 1991, April 23, 1991, and April 14, 1992. Eighteen sites were sampled in each Lagrangian survey (Table 1, Fig. 1).

Water samples were collected with a USGS D77 or DH77 water sampler using the equal-width increment, depth-integration method (Guy and Norman 1970), taking 10 to 30 vertical sections across the stream width. Grab samples were also collected when stream width was too narrow and depth too shallow to use either the D77 or DH77 sampler. All water collected at a site was composited in a stainless steel container then split with a ten-port Teflon splitter (USGS designed) into 1-liter glass jars. Split samples were analyzed for total suspended sediment

(TSS), total organic carbon (TOC), organophosphate insecticides (OPs), carbamate insecticides (CBs), and endosulfan (Tables 2 and 3).

Water Quality Measurements

Water quality parameters measured *in situ* include water temperature, pH, dissolved oxygen (DO), electrical conductivity (EC), and ammonia. Stream discharge was also measured at sites without gaging stations. Water pH was measured with a Cole Parmer ATC pH wand (model 05830-00). Dissolved oxygen was measured with a YSI (Yellow Springs Instruments) dissolved oxygen meter (model 57). Electrical conductivity was measured with a YSI salinity-conductivity-temperature (SCT) meter (model 33). Ammonia was estimated in the field using an ammonia-nitrogen test kit made by CHEMets (model AN-10). Discharge at each site was calculated by measuring stream velocities (using the six-tenths-depth and two-point methods) then summing these velocities across the stream width (Buchanan and Somers, 1969). Velocities were measured using a Price AA current meter (Buchanan and Somers, 1969).

Total suspended sediment and TOC were also measured. To measure TSS, 100 to 200 mL of sample were passed through a pre-cleaned 0.45 µm filter in accordance with USGS procedures (Fishman and Friedman, 1989). The method detection limit is 0.3 mg per sample. To measure TOC, a Dohrmann DC-85A TOC analyzer was used in accordance with instrument instructions (Dohrmann, Santa Clara, CA). The method detection limit for this procedure is 4 mg/L.

Pesticide Analysis

Water samples were screened for organophosphate (OP) and carbamate (CB) insecticides (Tables 2 and 3), and endosulfan (I, II, and sulfate forms). When the study began in 1991, the OP and CB screens were not complete, i.e. additional insecticides were still being tested for addition to the screens. Therefore in 1991, the OP screen consisted of three parent insecticides and three breakdown products, the CB screen consisted of four parent insecticides, and the endosulfan screen consisted of endosulfan I, II, and sulfate (Table 2). In 1992, the OP screen consisted of 12 parent and nine breakdown products, the CB screen consisted of six parent and three breakdown products (Table 3). In 1992, to preserve chemical constituents added to the OP and CB screens, samples were acidified to a pH of 3.0. In most cases, these insecticides were adequately preserved at pH 3.0 for at least 2 weeks in storage at 4°C (Ross, et al. 1996). However, diazinon broke down rapidly at this pH and therefore was analyzed in the endosulfan sample, which was not pH adjusted.

Organophosphate Screen

The OP screens were performed by the California Department of Food and Agriculture (CDFA) laboratory in both years. Water samples (1L) were extracted with 100 mL methylene chloride by shaking for 2 min. The methylene chloride layer was drained through 20 g sodium

sulfate and transferred to a 500 mL round bottom flask. The sample was extracted two more times, dried, and added to the round bottom flask. The solvent was evaporated to dryness using a rotary evaporator at 35°C and transferred with one 5-mL rinse, and two 2-mL rinses with acetone, to a calibrated tube. The extract was reduced to 0.5 mL under N_2 without heat, and brought to a final volume of 1 mL with acetone. Analysis was performed by gas chromatography (GC) using a Varian Model 6000 (Varian, Palo Alto, CA) or a Hewlett Packard GC model HP-5890 (Wilmington, DE), equipped with a flame photometric detector and a Hewlett Packard, HP-1 methyl silicone-gum column (10 m by 0.53 mm by 2.65 µm). Initial oven temperature was 150°C, held for one min, and increased to 200°C by 10°C/min, and held for two min. This temperature was then increased to a final temperature of 250°C by 20°C/min and held for five min. Injector and detector temperatures were 220°C and 250°C, respectively. Method detection limits are listed in Tables 2 and 3. Method validation recoveries can be found in Ross, et al. (1996).

Carbamate Screen

The CB screen was performed by Enseco-Cal laboratory in spring of 1991, then by CDFA in spring of 1992. In addition, CDFA also analyzed all water samples for carbofuran in 1991, since they had a lower detection limit for this analyte than Enseco-Cal laboratory. The switch to CDFA laboratory was made in 1992 because that laboratory added the analytes needed by DPR, had lower detection limits for all carbamates, and had more precise and accurate quality control results than Enseco-Cal.

Water samples (200 ml) analyzed by Enseco-Cal in 1991 were extracted using two C_{18} solid phase extraction (SPE) columns in series. Both SPE columns were eluted with 3.0 ml of methanol and collected in an 8-ml test tube. The eluant was reduced under N_2 to 0.3 - 0.5 ml, adjusted to a final volume of 1.0 ml with monochloroacetic acid and transferred to a 4-ml vial. Analysis was conducted using a Waters Liquid Chromatograph pump system equipped with a Phenomenex Hypersil C-8 column (4.6 mm x 6 cm by 3 µm) and a Finnigan TSQ-70 Thermospray Mass Spectrometer/Mass Spectrometer. A water-acetonitrile gradient was used to separate the analytes. Method detection limits are listed in Tables 2 and 3; method validation recoveries can be found in Ross, et al. (1996).

Water samples (100 g) analyzed by CDFA were extracted using three 100-mL aliquots of methylene chloride, shaking vigorously for one min. Solvent layers from all three extractions were poured into a 500 mL round bottom flask and concentrated to 3-5 mL on a rotary evaporator at 30-35°C. About one g of sodium sulfate was used to remove any water from the concentrate and then filtered through a 0.45 µm filter into a calibrated tube. The flask was rinsed with two 2-mL aliquots of methylene chloride and filtered through the same filter into the same tube. The extract was reduced to dryness under N_2 at 35°C, brought to a final volume of 0.2 mL with methanol, and mixed for about 15 sec using a vortex. Immediately prior to high performance liquid chromatography analysis, 0.9 mL of water were added and the sample mixed for about 15 sec using a vortex, and transferred to an autosampler vial. Analysis was performed using a Hewlett Packard 1090 Liquid Chromatograph equipped with a C18 column

(4.6 mm by 25 cm by 5μm), a Pickering Labs post-column derivatization system (Pickering Labs, Mountain View, CA) and a Hitachi F1000 fluorescence spectrometer set at 340 and 450 nm excitation and emission wavelengths, respectively. A water-acetonitrile gradient was used to separate the analytes. Method detection limits are listed in Tables 2 and 3; method validation recoveries can be found in Ross, et al. (1996).

Diazinon and Endosulfan Screens

Water samples (about 1 L) were extracted twice with 100 mL and once with 80 mL aliquots of methylene chloride, shaking for 1.5 min, venting often. Solvent layers were drained through 30 g sodium sulfate into a 500 mL flat-bottomed boiling flask. The sodium sulfate was rinsed with three 10-mL aliquots of methylene chloride and added to the flask. The extract was evaporated just to dryness on a rotary evaporator at 40°C and transferred to a calibrated tube using 8 to10 mL of acetone and brought to a final volume of 2 mL under N_2 at 40°C.

For diazinon, analysis was performed by GC using a HP 5890 equipped with a flame photometric detector and a HP-1, methyl silicone gum column (10 m by 0.53 mm by 2.65 μm). Initial oven temperature was 150°C, held for two min, and increased to a final temperature of 200°C (held for one min) by 10°C/min. Injector and detector temperatures were 220°C and 250°C, respectively. Method detection limits are listed in Tables 2 and 3; method validation recoveries can be found in Ross, et al. (1996).

For endosulfan, a florisil clean-up procedure was used, when necessary, prior to analysis. The extract solvent was exchanged from acetone to hexane under N_2 at 35°C. Extract was poured into a column filled with 10 cm heat-activated florisil, topped with 12 mm sodium sulfate and pre-wet with 50 mL hexane. The extract was loaded quantitatively to the column and eluted with 200 mL of a 50% diethyl ether:hexane (containing 10-25 g anhydrous sodium sulfate) and collected in a 500 mL flat-bottomed boiling flask. The eluant was reduced to 2 mL on a rotary evaporator at 40°C, transferred to a calibrated tube using 8 to 10 mL hexane, and brought to final volume of 2 mL under N_2 at 40°C. Analysis was performed by GC (Varian Model 6000) equipped with an electron capture detector and a HP-1 capillary column, 25 m by 0.2 mm by 0.33 μm. Initial oven temperature was 150°C, held for two min, and increased to 250°C by 25°C/min, and held for six min. Injector and detector temperatures were 230°C and 300°C, respectively. Method detection limits are listed in Tables 2 and 3; method validation recoveries can be found in Ross, et al. (1996).

Quality Control

As part of a quality control (QC) program, data generated during method validation (see Ross, et al. 1996) were used to assess all subsequent study results. Specifically, method validation data were used to establish warning and control limits similar to that described by Miller and Miller (1988). A warning limit is the mean ± 2s, where the mean is the average % recovery found in method validation and s the standard deviation. A control limit is the mean ± 3s.

Continuing QC samples consisted of water samples spiked with an analyte at a given concentration, extracted and analyzed with each extraction set (Appendix I). An extraction set consists of one to 13 field samples, and depends on how many samples are received in the laboratory for processing at any one time. During the course of the study, continuing QC samples are compared back to the warning and control limits. If a continuing QC sample exceeds the warning limit, the chemist is notified. If the continuing QC sample exceeds the control limit, corrective measures are taken in the lab to bring conditions back under control. Only field samples potentially low in concentration, as indicated by QC results that are below the lower control limit, are noted in the report. In addition, blind spikes were analyzed (Appendix II). A blind spike is a surface water sample that is spiked by one chemist and submitted to another for analysis. The analyte and concentration of blind spikes is therefore not known by the chemist performing the analysis.

As an additional quality assurance measure, a total of 11 field-rinse samples were prepared during the two spring surveys. All sampling equipment was cleaned in the field using three distilled-water rinses after sample collection. Field-rinse samples were prepared by pouring distilled water into all sampling equipment after a typical cleaning procedure. These samples were then collected in one-liter amber glass jars, as was done for all water samples. Field-rinse samples were transported and stored with other water samples, and analyzed for all insecticides as well as TSS and TOC. Field-rinse samples served as a check on potential sample contamination during collection, transport, and storage. Insecticides were not detected in these samples, however in 1991, both TSS and TOC were found (Appendices III and IV). To improve cleaning procedures, an additional distilled-water rinse was added before the spring 1992 sampling period. Subsequently, neither TSS nor TOC was detected in field-rinse samples (Appendices III and IV).

RESULTS AND DISCUSSION
Pesticide and Land Use

A number of insecticides are used during spring months (March and April) in the San Joaquin Valley (DPR, PUR databases 1991 and 1992). In spring, use of chlorpyrifos, diazinon, malathion, carbaryl, and carbofuran is generally higher than use of the other insecticides examined in this study (Table 4, PUR 1991 and 1992). During the spring of 1991, chlorpyrifos use totaled 54,000 lbs, diazinon 15,000 lbs, malathion 31,000 lbs, carbaryl 10,000 lbs, and carbofuran 34,000 lbs in Merced, Stanislaus, and San Joaquin Counties. In the spring of 1992 use totaled 77,000 lbs, 20,000 lbs, 29,000 lbs, 11,000 lbs and 45,000 lbs for chlorpyrifos, diazinon, malathion, carbaryl, and carbofuran, respectively.

Of the nine insecticides detected during the spring, eight are applied to alfalfa in Merced, Stanislaus, and San Joaquin counties (Table 5). Alfalfa is a perennial crop grown under a wide variety of conditions in every county of the state of California. An alfalfa stand usually remains in place for three to four years and is harvested a number of times during a single year (IPM for Alfalfa Hay, University of CA Statewide IPM project, Division of Agricultural Sciences, UC Davis 1981). As a perennial crop, alfalfa provides habitat for a number of organisms, some pests, some not. Of the nearly 1000 species common to alfalfa in California, six or seven species significantly affect crop yields (IPM 1981) and may require insecticide use for control. Chlorpyrifos, diazinon, malathion, and carbofuran are typically used during the spring season on alfalfa to control aphids and weevils. Only minor use (<1,050 lbs) of dimethoate, ethyl parathion, methidathion, and carbaryl was reported for alfalfa in 1991, while there was no reported use for oxamyl and endosulfan (Table 5).

In addition to alfalfa, another major use category is structural pest control (Table 5) where malathion and carbaryl are used to control a variety of home and garden insects and other invertebrate pests.

Any discussion of insecticides found in surface water during the spring season should also mention use of insecticides during the dormant spray season (January and February, Table 6). Some have a relatively long half-life in soil (e.g. 40 days for diazinon and 57-180 days for chlorpyrifos: Kollman and Segawa 1995) and therefore sufficient residence time for transport to surface water after their peak use period. Chlorpyrifos, diazinon, and methidathion are the major insecticides used to control over-wintering pests in fruit and nut trees in these counties (Table 6) and are known to move off-site in rain runoff (Ross 1997). Ethyl parathion was also commonly used as a dormant spray insecticide prior to the U.S. EPA ban at the end of 1991. Use of remaining stocks was permitted after 1991, which accounts for the relatively small amount reported in 1992 (Table 4).

Quality Control

All continuing QC sample results are listed in Appendix I. For the OP screen, 247 continuing QC spikes were made during the two spring seasons (Appendix I and Table 7). Of these, 9 were above the upper control limits, indicating analytical results may over-estimate the actual concentration about 3.6% of the time. Of the 247 continuing QC spikes, four fell below the lower control limits and all were for ethyl parathion in spring 1992 (Table 7). Of 135 CB spikes, eight (5.9%) were above and seven (5.2%) were below the control limits (Table 7). Of 122 endosulfan screen spikes, three (2.5%) were above and zero below the control limits (Table 7). Field samples analyzed with continuing QC values below the lower control limit are noted in the data tables. Potential over estimation of a concentration was not reported for two reasons: 1. Most field samples analyzed with continuing QC samples above the control limit were none detects, and 2. errors on the high side are more conservative where environmental protection is concerned.

There were 12 blind-spike samples analyzed for the spring season (Appendix II). All were within the control limits for this study except one ethyl parathion sample from 1992, which exceeded the upper control limit. Ethyl parathion results were not consistently under control for this study since four continuing QC samples were below and one spike sample above the control limits. It is therefore recommended that we re-evaluate the continued inclusion of ethyl parathion in the OP screen.

Water Quality Objectives and Criteria

Water quality measurements and insecticide concentrations will be compared with acute objectives and criteria designed to protect freshwater aquatic life. Objectives established by the CVRWQCB (1994) will be used as the primary comparison. If the CVRWQCB has not established an objective for this watershed, the most recent U.S. EPA freshwater criterion (1986 and 1987) will be used. If the U.S. EPA has not established a criterion, the water quality criterion suggested by the California Department of Fish and Game (CDFG) will be used. The criteria established by these agencies were selected for comparison because they follow established U.S. EPA methodology for criteria development (Stephan, et al. 1985).

In addition, comparisons will be made only with acute objectives and criteria since samples collected in this study were short-term in nature (*i.e.*, samples took anywhere from a few minutes to one hour to collect). Comparison with chronic values is not appropriate under these circumstances since chronic criteria are applied to longer time periods. For example, U.S. EPA chronic criteria require averaging over a four-day period. Measurements in this study reflect a maximum of two hours, during any given 96-hour (4-day) period. Large variation in concentrations exist even when measurements are made once a day. For example, on the SJR at Vernalis during winter months, a four day average concentration of diazinon for samples collected once daily, can have a coefficient of variation of 70% during rain events (see MacCoy

et al., 1995, sampling dates Feb. 10-13, 1994), and 74% during dry periods (see MacCoy et al., 1995, sampling dates Feb. 15-18, 1994). Due to the large variation even in once daily sampling, comparisons with chronic criteria were not made.

Finally, acute criteria are site specific, *i.e.,* criteria are not to be exceeded more than once every three years, on average, at a given location (Stephan, et al. 1985). Therefore, comparisons with acute criteria will be made on a site by site basis using the data available.

Water Quality Measurements

Temporal Variation at Laird Park

Water quality measurements were made at Laird Park (site 12) twice weekly in March and April of 1991 and 1992 (Fig. 2, Appendix III). Water temperatures at the time of sampling ranged from 13 to 22°C and pH ranged from 7.4 to 8.3. None of the pH values were below the minimum or above the maximum water quality objectives established by the CVRWQCB (CVRWQCB, 1994; Table 8).

In addition to temperature and pH: DO, EC, and total ammonia were measured (Fig. 2, Appendix III). Dissolved oxygen ranged from 7.2 to 12 mg/L, with none below the CVRWQCB objective of 5.0 mg/L for this warm water habitat (see CVRWQCB, 1994, for habitat designations). Electrical conductivity ranged from 542 to 2470 µS/cm. These EC values are similar to those reported before in the SJR (Shelton and Miller, 1988; Anderson et al., 1990). Water quality objectives and criteria have not yet been established for this parameter in this portion of the watershed. However, 700 µS/cm has been suggested as an agricultural water quality goal (Marshack, 1998). Total ammonia ranged from 0.2 to 2 mg/L. Criteria for ammonia concentrations are dependent on water temperature and pH. Ammonia concentrations at Laird Park (site 12) did not exceed the criteria recommended by the U.S. EPA (US EPA, 1986).

Total suspended sediment ranged from 62 to 460 mg/L (Fig. 2, Appendix III). Numerical objectives for this parameter have not been established. However, high amounts of suspended sediment may cause changes in the aquatic system including increased drift of benthic organisms (White and Gammon, 1976; Rosenberg and Wiens, 1978), high mortalities of benthic plants and invertebrates, decreased light penetration, changes in foraging and mating behavior of certain organisms, and clog gills of some animals impairing respiration (Connell & Miller 1984). However, from the data collected in this study, it is not known if any of these changes occurred in the watershed.

Total organic carbon ranged from <4 to 18 mg/L (Fig. 2) and fell within the range of concentrations measured previously in the SJR (Shelton and Miller, 1988; Anderson et al., 1990). Numerical objectives for this parameter have not been established.

Lagrangian Surveys

Water temperatures varied with location and date of survey, and ranged from 15 to 24°C (Fig. 3, Appendix IV). The pH ranged from 6.7 to 8.7, and on two occasions, exceeded the 8.5 maximum objective established by the CVRWQCB (CVRWQCB, 1994; Table 8). These occurred at Del Puerto Creek (site 11) on April 4, 1991, and at SJR at Stevinson (site 1) on April 23, 1991. The reason why the objective was exceeded is not clear from the data collected.

Dissolved oxygen ranged from 3.4 to >12 mg/L (Fig. 3), values indicating deoxygenated and super-saturated conditions, respectively. Four measurements were below the CVRWQCB objective established for warm water habitats (Table 8). Two of the four measurements were made in the Newman Wasteway (site 5), where DO ranged from 3.4 to 4.0 mg/L. The Newman Wasteway is a cement lined ditch built to move operational spill water from the Delta Mendota Canal and to drain nearby agricultural land. Water in this conveyance is frequently slow moving or stagnant, which may contribute to low DO values. One of the four measurements were made in TID #5 (site 9). This site frequently carries waste water from a waste water treatment plant operated by the city of Turlock. Primary waste water treatment plants may discharge high amounts of ammonia and organic carbon (see below), increasing the biological oxygen demand in the receiving waters, thereby reducing the amount of oxygen dissolved in the water (Tchobanoglous and Schroeder, 1985). The remaining DO measurement below the objective occurred once at Los Banos Creek (site 4). All three of these sites had low DO measurements reported in the SJR winter report (Ross, et al. 1996).

Electrical conductivity ranged from 83 µS/cm at the Tuolumne River (site 13) to 4200 µS/cm at Mud Slough (site 3; Fig. 3). The Merced, Tuolumne, and Stanislaus Rivers (sites 6, 13, and 16) were all consistently below 700 µS/cm, a suggested agricultural water quality goal mentioned by Marshack (1998). This proposed goal was exceeded at least once at all other sites measured during the three Lagrangian surveys. Overall, the highest EC values were reported at sites in the southern reaches of the watershed (Fig. 3). These sites are located in or near Kesterson National Wildlife Refuge, an area traditionally high in selenium and other salts, contributing to high EC of the waters in this area (CVRWQCB, 1988).

Total ammonia ranged from <0.1 to >10 mg/L (Fig. 3), values above and below the detection limits. Turlock Irrigation District drain #5 (site 9) had the highest total ammonia concentrations of all sampling sites. In addition to being downstream of a waste water treatment plant, this site is located adjacent to a rendering plant, which in the past was a source of ammonia. There are also a number of dairies that discharge into TID #5, another potential source of ammonia in this drain. It is unknown whether the U.S. EPA criteria for ammonia were exceeded at this site since all concentrations were above the upper limit of the test. Ammonia concentrations measured at all other sites were below the U.S. EPA's water quality criteria for the protection of aquatic life.

During the Lagrangian survey, TSS ranged from 10 to 780 mg/L (Fig. 3). The highest TSS concentrations occurred in Ingram/Hospital, Orestimba, and Del Puerto Creeks (sites 14, 8, and 11, respectively). These creeks are located on the west side of the SJR, an area of fine textured soils prone to erosion.

Total organic carbon concentrations ranged from <4 to 300 mg/L (Fig. 3), with the highest concentration found at TID# 5 (site 9). Total organic carbon tends to be high in areas of human and animal waste discharges (Tchobanoglous and Schroeder, 1985). Aside from the single high TOC value at TID #5, all other TOC concentrations were ≤ 32 mg/L.

Temporal Variation in Insecticide Concentrations

Organophosphates

Chlorpyrifos was detected in two of 32 samples collected during the temporal survey at Laird Park (site 12, Table 9). Neither detection, exceeded the acute criterion of 0.083 µg/L established for the protection of freshwater aquatic life (U.S. EPA, 1987).

Diazinon was detected in 7 of 18 samples collected during the temporal survey in 1992 (Table 9). Diazinon detections ranged from 0.05 to 0.10 µg/L. Numeric objectives and criteria for the protection of aquatic life have not been established by the CVRWQCB or U.S. EPA for diazinon. The CDFG has suggested that "... freshwater aquatic organisms should not be affected unacceptably if the one-hour average concentration does not exceed 0.08 µg/L more than once every three years" (Menconi and Cox 1994). Of 18 samples, residues in three samples exceeded the suggested criterion at this site.

Malathion was detected in three of 32 samples collected during the temporal survey at Laird Park (site 12, Table 9). Concentrations ranged from 0.05 to 0.08 µg/L. None of these detections exceeded the suggested acute criterion of 0.43 µg/L established by CDFG for the protection of aquatic life (Siepmann and Slater, 1998).

Methidathion was detected in one of 18 samples analyzed for this insecticide during the 1992 temporal survey (Table 9). Acute criteria for the protection of aquatic life have not been established for this insecticide.

Carbamates

Carbofuran was detected at Laird Park (site 12) in five of 30 samples at concentrations from 0.05 to 0.12 µg/L (Table 9). Numeric criteria for the protection of freshwater aquatic life have not yet been established for carbofuran (Table 8).

Endosulfan

The concentration for total endosulfan was calculated using the formula:

Total Endosulfan = I + II + (0.96217*sulfate)

The weighting factor for endosulfan sulfate accounts for the difference in molecular weight between the sulfate and the endosulfan I and II isomers. This concentration was then compared with the U.S. EPA acute freshwater criterion of 0.22 µg/L for total endosulfan (Table 8).

Endosulfan (I, II, and/or sulfate) was detected in seven of 32 samples. Total endosulfan concentrations ranged from the detection limit (0.005 µg/L) to 0.033 µg/L. These detections were all below the acute criterion. In addition, endosulfan I and II have a U.S. EPA acute criterion of 0.22 µg/L, individually. This concentration was also not exceeded.

Rainfall and Temporal Variation in Insecticide Residues

Both water years 1991 and 1992 were considered critically dry years in the Sacramento-San Joaquin Basins (DWR 1992). Monthly rainfall recorded in Modesto totaled 4.25 and 0.43 inches in March and April of 1991, 236% and 36% of average monthly rainfalls, respectively (DWR 1991). In 1992, rainfall totaled 1.80 and 0.07 inches for March and April, 108% and 6% of monthly averages, respectively (DWR 1992). Annual rainfall for this station was 8.05 and 11.28 inches for 1991 and 1992, respectively, 67% and 94% of the annual average at this station, respectively.

Carbofuran concentrations occurred at Laird Park after peak use in the region and just after a rainy period began in mid-March of 1991 (Figure 4). Peak carbofuran concentrations occurred just prior to peak discharge, a pattern similar to other SJR studies during the dormant spray season (Ross et al., 1996; Domagalski 1995; Kuivila and Foe 1995). The main factors involved in insecticide transport to the SJR appear to be timing of insecticide application relative to storms generating runoff (Panshin et al., 1998; Ross et al., 1996).

Diazinon detections were associated with peak use in mid-March of 1992 (Figure 5). In addition, it appears detections occurred after peak discharge at Laird Park (site 12). However, discharge varied very little during March and April of 1992 due to the low amount of rainfall received for the year. Transport processes other than rain runoff, e.g. irrigation runoff and aerial drift, may be important during dry periods. Irrigation runoff may be predominant at this time of year during critically dry years, while aerial drift may take on more importance with sufficient rainfall in December, January, and February. Other researchers have provided some evidence for the importance of irrigation runoff (Dubrovsky et al., 1999) and aerial drift (Poletika, 1999) in pesticides studies of the San Joaquin River watershed.

Lagrangian Surveys

Organophosphates

Chlorpyrifos was detected in three of 53 samples collected during the Lagrangian surveys, all detections were found in the April 23-26, 1991 survey. Chlorpyrifos use is relatively high on

both almonds and alfalfa (Tables 5 and 6), and occurs January through April (Table 4). Concentrations ranged from 0.05 to 0.23 µg/L (Table 10). The highest detection was measured in TID#5 (site 9), followed by a detection in the SJR at Patterson (site 10), just downstream of the confluence with TID#5, followed by the last detection at Laird Park (site 12). It appears TID#5 was the source of residues seen in the SJR during the April 24, 1991 survey. One sample exceeded the 0.083 µg/L value, however it is not known from these data and our winter data (Ross, et al., 1996) if other concentrations exceeded this value during a three year period at this site.

Diazinon was detected in two of 18 samples collected (Table 10). and concentrations ranged from 0.06 to 0.52 µg/L. The highest concentration, 0.52 µg/L, was found in Orestimba Creek (site 8) on April 15, 1992. In agricultural areas of the Orestimba Creek basin and the Central California Irrigation District basin that periodically discharges into Orestimba Creek, diazinon is mainly used as a dormant spray on almonds, with spring use on alfalfa. The remaining diazinon detection found in Salt Slough was below the CDFG suggested criterion of 0.08 µg/L.

Dimethoate was detected in two of 18 samples (Table 10) during the April 14-17, 1992 survey. Dimethoate concentrations were 2.2 µg/L in the Newman Wasteway (site 5) and 0.18 µg/L in Ingram/Hospital Creek (site 14). Dimethoate is used almost exclusively in March and April on alfalfa, wheat, grapes, and tomatoes. Numeric criteria to protect freshwater aquatic life have not yet been established for dimethoate.

Carbamates

Carbaryl was detected in one of 18 samples collected during the 1992 Lagrangian survey in Ingram/Hospital Creek at a concentration of 0.44 µg/L (Table 10). Carbaryl is used mainly for structural pest control and has some dormant spray use (Tables 5 and 6). The CDFG acute criterion of 5.05 µg/L (Table 8, Siepmann and Jones 1998) was not exceeded during these surveys.

Carbofuran was detected in 12 of 53 samples, ranging in concentration from 0.05 to 0.60 µg/L (Table 10). Numeric criteria to protect freshwater aquatic life have not yet been established for carbofuran.

Oxamyl was detected in nine of 53 samples, ranging in concentration from 0.05 to 0.27 µg/L (Table 10). Oxamyl detections originate in Salt Slough (site 2) and are carried as far north as Laird Park in the SJR. Numeric criteria to protect freshwater aquatic life have not yet been established for oxamyl.

Endosulfan

Endosulfan (isomers I, II, and/or sulfate) was detected in 13 of 51 samples (Table 9). The highest detection of total endosulfan (0.25 µg/L), found in Ingram/Hospital Creek, was above the U.S. EPA acute criterion of 0.22 µg/L. The next highest detection, also found at this site was 0.21 µg/L. Due to past fish kills attributed to endosulfan and concentrations in certain

watersheds of the state above U.S. EPA acute criteria, DPR recommended in 1991 that endosulfan use be permitted only on properties that do not drain into surface water. In the 1992 survey, only endosulfan sulfate was detected in the SJR indicating no new material had been transported to our sampling sites at the time of sampling. Any future monitoring should consider additional chemical analysis to confirm that recommended use practices remain effective in reducing endosulfan movement to surface water.

Mass Loading of Insecticides

Mass loading calculations are useful for (a) determining major sources of contaminants, (b) estimating instantaneous, daily, annual, or storm event loads, and (c) providing information about the behavior of contaminants during transport in a watershed. Mass load calculations and diagrams were made for carbofuran, endosulfan, and oxamyl (Fig. 6). Mass loads at any given site in the SJR below a tributary should be equal (within +/- 30%, based on chemical analytical and discharge measurement variability, see Ross, et al., 1996). Deviations from this indicate potential sources that weren't sampled (such as direct field inputs), sinks for the insecticide (i.e. losses from the system), and/or non-Lagrangian sampling (i.e. sampling of the same parcel of water did not occur).

In most cases, true Lagrangian sampling was achieved and the mass loading diagrams for all three insecticides, carbofuran, endosulfan, and oxamyl, showed similar results (Fig. 6). Salt Slough and the west-side tributaries contributed all the residues detected in the SJR. Dilution from east-side tributaries occurred such that residues of carbofuran and oxamyl were not detected in the SJR at Vernalis. (The endosulfan samples from Vernalis were broken prior to analysis.)

Insecticide use patterns for the spring season were not always consistent with surface water detections. Use patterns for carbofuran in 1991 showed widespread use throughout the watershed, on the east as well as the west side of the SJR (Fig. 7) yet only west-side tributaries carried detectable residues (Fig. 6). This pattern may be related to the soil types in the two regions. East-side soils are coarse grained and highly permeable while west-side soils are fine textured and highly erodible. Given small amounts of rainfall or irrigation, such as occurred in April 1991, the soils on the east-side are capable of infiltrating this amount of water. Soils on the west-side are not as permeable and tend to generate more surface runoff, carrying with it more insecticide. Hence, detections of carbofuran occurred in west-side and not east-side tributaries.

In contrast, the use pattern for oxamyl was more consistent with residues detected in the watershed. However, oxamyl use was more concentrated than carbofuran which might partially explain the detections reported. The highest use occurred in the southern portion of the SJR watershed in the Salt Slough drainage area (see Panshin, et al., 1998 for basin boundaries), where the highest mass loading also occurred (Fig. 8). Another area of use was Del Puerto

Creek, an additional source of oxamyl to the SJR. The last area of use was the Ingram/Hospital Creek basin but oxamyl was not detected there at the time of sampling. Use in the later two basins was quite small, less than 300 lbs combined, so it is not surprising that detections were not always consistent with application locations.

Finally, endosulfan use in the months of January, February, March, and April 1991, was not consistent with detections in the watershed (Fig. 9). For example, the highest endosulfan concentrations were found in Ingram/Hospital Creek yet there was no reported use during the months of January - April of 1991. Endosulfan has a relatively long half-life which may account for this apparent discrepancy (see below).

Physical-Chemical Properties and Insecticide Occurrence

In addition to total use and application location, physical and chemical properties of the insecticides are important for describing surface water residues. For example, oxamyl use is at least an order of magnitude lower than chlorpyrifos use yet it was detected almost twice as often. Oxamyl is an extremely soluble pesticide (2.82×10^5 mg/L), with low soil adsorption ($K_d = 0.15$), an 8-day hydrolysis half-life at neutral pH, and a sufficient field dissipation half-life (55 days) to be available for runoff (Table 11). In contrast, chlorpyrifos is not very soluble in water (1.4 mg/L), has high soil adsorption ($K_d = 125$), a hydrolysis half-life of 72 days at neutral pH, and has reported field dissipation half-lives between 33 and 56 days (Table 11). The main difference between the two insecticides appears to be solubility. Therefore, with highly soluble materials, even with little use, there is a greater potential for mass movement into surface water than for less soluble, higher use compounds. It should be noted that suspended sediment was not filtered from the water sample, nor was sediment load in the samples determined. From field runoff studies (Ross, et al., 1997), the mass runoff of sediment bound chlorpyrifos was much lower than the mass runoff of methidathion, another water soluble insecticide, indicating the more soluble chemicals contribute higher runoff mass than the less soluble ones. However, to obtain a true comparison between oxamyl and chlorpyrifos, sediment loads and sediment bound materials should be analyzed.

Longevity of an insecticide and its degradation products may also play a role in detection. For example, endosulfan had no reported use in the Ingram/Hospital Creek or Del Puerto Creek basins three months prior to sampling, yet the highest concentrations were found there. However, use in these regions was quite high in June, July, August, and September of 1990 (PUR, 1990). In addition, aerobic soil half-lives for endosulfan range from 26 to 38 days and field dissipation half-lives from 77 to 93 days (Table 11). Soil adsorption may also be a factor since this insecticide is tightly bound to soil (K_d ranges from 63 to 523, Table 11) leaving endosulfan residues attached to soil in creek beds and on field, making it available for resuspension in creeks and field runoff for long periods of time. Therefore, it appears that a long field half-life, coupled with a tightly bound chemical in a region of high soil erosion, may contribute to detections seen months after application.

CONCLUSIONS

Nine insecticides were detected during spring months in the SJR watershed. Diazinon and endosulfan were detected in 25% and 24% of the samples analyzed for each analyte. Carbofuran was the next most frequently detected insecticide (found in 20% of the samples), followed by oxamyl (11% of the samples). The remaining insecticides were less frequently detected (<6% of the samples).

The U.S. EPA has acute criteria for the protection of freshwater aquatic life for two of the insecticides detected in this study, chlorpyrifos and endosulfan. Each chemical had one detection above this criterion. Currently there are no restrictions on chlorpyrifos use, however a voluntary effort to control chlorpyrifos residues during dormant season is underway. Potentially, efforts may need to extend to spring uses as well. Additional monitoring in spring months would help determine if this is necessary. Restrictions on endosulfan use were implemented in 1991, as a result of fish kills and detections in other watersheds in the state. Subsequently, detections in the SJR were below the acute criterion in 1992. Additional monitoring in spring months should be conducted to determine if recommended restrictions continue to be effective in reducing endosulfan levels in this watershed.

Lagrangian surveys were useful for identifying tributaries contributing insecticide loads to the SJR, particularly since use patterns do not entirely explain the residue patterns seen in the watershed. Salt Slough and the west-side tributaries carried carbofuran, oxamyl, and endosulfan residues into the SJR. East-side tributaries carried dilution water and did not contain detectable residues of the insecticides measured in this study during the spring season. The fine-textured, highly erodible soils of the west side compared with the coarse-grained, permeable soils of the east side may partially explain the differences seen. In addition, the physical and chemical properties of the insecticides aided in interpretation of detections. Therefore, although use patterns were helpful for interpreting insecticide patterns, they alone were not sufficient.

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Table 1. Number, name, and location of sites used in the San Joaquin River (SJR) study.

Site #	Site Name	Site Description, Latitude and Longitude Coordinates (deg min sec)
1	SJR near Stevinson @ Highway 165	1 mi. S. Hwy 140 & Hwy 165 intersection 37 17 44 120 50 60
2	Salt Slough @ Highway 165	37 14 52 120 51 04
18	SJR @ Fremont Ford	37 18 37 120 55 46
3	Mud Slough	U.S.G.S. gaging station in Kesterson National Wildlife Refuge 37 16 33 120 55 11
4	Los Banos Creek @ Highway 140	Intersection with Highway 140 37 16 36 120 57 16
5	Newman Wasteway	Behind the city of Newman waste water treatment facility 37 19 17 120 58 52
6	Merced River @ Hatfield State Recreation Area.	37 21 01 120 57 40
7	SJR @ Hills Ferry Rd.	37 20 58 120 58 31
8	Orestimba Creek @ River Rd.	37 24 52 121 00 49
9	TID #5	Turlock Irrgiation District Drain #5 at Carpenter Rd. 37 27 52 121 01 48
10	SJR @ W. Main St.	37 29 39 121 04 46
11	Del Puerto Creek	North of terminus of Loquat Ave. 37 32 21 121 07 14
12	SJR @ Laird Park	37 33 42 121 09 06
13	Tuolumne River @ Shiloh Rd.	37 36 12 121 07 50
14	Ingram/Hospital Creek	S.E. of Dairy and Pelican Rd. 37 36 57 121 12 15
15	SJR @ Maze Blvd.	37 38 27 121 13 40
16	Stanislaus River @ Caswell Memorial State Park	37 41 43 121 12 10
17	SJR near Vernalis @ Airport Rd.	37 40 33 121 15 51

Table 2. Method detection limits (µg/L) for pesticides and degradation products analyzed in the organophosphate, carbamate, and endosulfan screens in the 1991 spring season. Analyses performed by the California Department of Food and Agriculture Laboratory, except where indicated.

Organophosphates	mdl[a]	Carbamates	mdl	Endosulfan	mdl
Chlorpyrifos	0.05	Aldicarb[c]	0.10	I	0.005
Chlorpyrifos OA[b]	0.10	Carbofuran	0.05	II	0.005
Malathion	0.05	Methiocarb[c]	0.10	sulfate	0.010
Malathion OA	0.10	Oxamyl[c]	0.10		
Phosmet	0.05				
Phosmet OA	0.20				

a. mdl = method detection limit.
b. OA = oxygen analog.
c. Analysis performed by Enseco-Cal laboratories.

Table 3. Method detection limits (µg/L) for pesticides and degradation products analyzed in the organophosphate, carbamate, and endosulfan screens in the 1992 spring season. Analyses performed by the California Department of Food and Agriculture Laboratory.

Organophosphates	mdl[a]	Carbamates	mdl	Endosulfan	mdl
Azinphos-methyl	0.05	Aldicarb	0.05	I	0.005
Azinphos-methyl OA[b]	0.30	sulfoxide	0.05	II	0.005
Chlorpyrifos	0.05	sulfone	0.05	sulfate	0.010
Chlorpyrifos OA	0.10	Carbaryl	0.05		
DDVP	0.05	Carbofuran	0.05		
Diazinon[c]	0.05	3-Hydroxy	0.05		
Diazinon OA[c]	0.05	Methiocarb	0.05		
Dimethoate	0.05	Methomyl	0.05		
Ethyl parathion	0.05	Oxamyl	0.05		
Ethyl parathion OA	0.05				
Malathion	0.05				
Malathion OA	0.05				
Methidathion	0.05				
Methidathion OA	0.10				
Methyl parathion	0.05				
Methyl parathion OA	0.05				
Phorate	0.05				
Phosalone	0.05				
Phosalone OA	0.05				
Phosmet	0.05				
Phosmet OA	0.30				

a. mdl = method detection limit.
b. OA = oxygen analog.
c. Diazinon and diazinon OA were analyzed with endosulfan. See text for explanation.

Table 4. Use of insecticides (lbs) in Merced, Stanislaus, and San Joaquin counties during the months of January, February, March, and April of 1991 and 1992. Use is summarized only for the insecticides detected in this study.

	Organophosphates						Carbamates			
Year/County	Chlorpyrifos	Diazinon	Dimethoate	Ethyl Parathion	Malathion	Methidathion	Carbaryl	Carbofuran	Oxamyl	Endosulfan
1991										
Merced										
January	8,610	10,600	NRU[a]	30,900	344	11,400	2,230	NRU	NRU	NRU
February	1,480	4,570	NRU	2,300	3,590	1,020	561	NRU	96	NRU
March	10,300	5,340	937	36	9,260	95	2,660	3,120	NRU	278
April	3,320	1,180	453	274	15,700	26	2,330	272	833	40
Stanislaus										
January	14,800	11,700	NRU	27,300	159	23,200	1,540	NRU	NRU	NRU
February	1,760	3,520	NRU	1,060	167	200	1,340	139	37	NRU
March	13,600	500	51	71	1,610	296	1,240	3,510	NRU	NRU
April	6,280	1,010	239	401	1,530	130	2,180	334	908	46
San Joaquin										
January	1,410	5,100	NRU	4,010	455	14,000	1,490	195	15	NRU
February	1,470	3,710	8	1,980	631	2,640	450	1,140	15	1
March	16,600	593	1	119	909	600	31	20,000	4	44
April	4,210	6,430	892	NRU	1,820	156	1,110	7,020	1,060	1,210

Continued on next page.

Table 4. Use of insecticides (lbs) in Merced, Stanislaus, and San Joaquin counties during the months of January, February, March, and April of 1991 and 1992. Use is summarized only for the insecticides detected in this study.

	Organophosphates						Carbamates			
Year/County	Chlorpyrifos	Diazinon	Dimethoate	Ethyl Parathion	Malathion	Methidathion	Carbaryl	Carbofuran	Oxamyl	Endosulfan
1992										
Merced										
January	10,400	25,900	NRU	1,040	3,790	6,170	676	NRU	NRU	NRU
February	4,410	10,800	NRU	13	116	7	15	394	NRU	NRU
March	10,500	7,070	381	20	19,200	323	323	2,510	73	287
April	8,340	2,770	875	NRU	3,060	139	1,680	187	1,640	NRU
Stanislaus										
January	20,200	29,500	NRU	576	116	11,400	3,520	NRU	NRU	NRU
February	3,220	4,370	NRU	190	79	NRU	40	371	50	NRU
March	14,600	1,440	137	NRU	566	136	466	2,640	NRU	248
April	12,400	968	686	NRU	1,080	393	3,340	103	210	42
San Joaquin										
January	2,210	25,300	25	706	80	6,360	355	506	10	2
February	4,710	7,550	24	667	55	1,810	54	898	11	NRU
March	20,600	1,860	338	61	668	596	773	32,600	10	34
April	10,500	5,940	316	NRU	4,150	188	4,000	6,730	286	2,340

NRU = no reported use.

Table 5. Use of pesticides (lbs) on crops grown in Merced, Stansilaus, and San Joaquin counties during the months of March and April of 1991.

	Organophosphates						Carbamates			
Commodity	Chlorpyrifos	Diazinon	Dimethoate	Ethyl Parathion	Malathion	Methidathion	Carbaryl	Carbofuran	Oxamyl	Endosulfan
alfalfa	43,200	4,890	1,040	119	17,400	451	412	27,800	NRU	NRU
almond	430	90	NRU[a]	NRU	NRU	33	5	NRU	NRU	NRU
apple	412	549	77	NRU	NRU	532	202	NRU	NRU	256
apricot	NRU	394	NRU	NRU	NRU	NRU	NRU	NRU	NRU	NRU
cherry	NRU	5,140	NRU	NRU	NRU	NRU	805	NRU	NRU	977
grape	120	37	304	32	NRU	NRU	57	6,370	NRU	NRU
greenhouse	484	94	5	NRU	NRU	NRU	8	NRU	17	6
peach	NRU	259	NRU	628	158	NRU	757	NRU	NRU	328
pepper	NRU	52	23	NRU	NRU	NRU	3	NRU	153	NRU
structural pest control	3,730	1,900	NRU	NRU	11,740	NRU	6,320	NRU	NRU	NRU
tomato	NRU	348	192	NRU	114	NRU	966	NRU	1,640	NRU
walnut	2,540	115	NRU	NRU	553	286	NRU	NRU	NRU	NRU
watermelon	NRU	NRU	NRU	NRU	NRU	NRU	NRU	NRU	802	NRU
wheat	1,120	NRU	864	NRU	292	NRU	NRU	NRU	NRU	NRU
other	2,251	1,196	68	122	536	0	23	99	198	53

NRU = no reported use.

Table 6. Use of pesticides (lbs) on crops grown in Merced, Stansilaus, and San Joaquin counties during the months of January and February of 1991.

	Organophosphates						Carbamates			
Commodity	Chlorpyrifos	Diazinon	Dimethoate	Ethyl Parathion	Malathion	Methidathion	Carbaryl	Carbofuran	Oxamyl	Endosulfan
alfalfa	555	NRU[a]	NRU	NRU	NRU	45	NRU	432	NRU	NRU
almond	25,700	30,600	NRU	51,900	133	40,600	823	NRU	NRU	NRU
apple	555	1,820	NRU	15	NRU	2,960	NRU	NRU	NRU	NRU
apricot	NRU	2,200	NRU	7,390	NRU	1,050	1,710	NRU	NRU	NRU
cherry	3	1,540	NRU	996	NRU	314	NRU	NRU	NRU	NRU
grape	NRU	NRU	NRU	198	NRU	NRU	32	1,040	NRU	NRU
greenhouse	78	51	NRU	NRU	NRU	NRU	12	NRU	29	1
peach	693	816	NRU	4,630	506	6,510	79	NRU	NRU	NRU
pepper	NRU	NRU	NRU	NRU	NRU	NRU	NRU	NRU	NRU	NRU
structural pest control	1,750	1,770	NRU	NRU	4,230	NRU	4,670	NRU	NRU	NRU
tomato	NRU	11	NRU	NRU	NRU	NRU	33	NRU	132	NRU
walnut	102	3	NRU	NRU	376	701	NRU	NRU	NRU	NRU
watermelon	NRU	NRU	NRU	NRU	NRU	NRU	NRU	NRU	NRU	NRU
wheat	NRU	NRU	NRU	NRU	NRU	NRU	NRU	NRU	NRU	NRU
other	94	389	8	2,421	101	280	252	2	2	0

NRU = no reported use.

Table 7. Results of continuing quality control samples analyzed during the 1991 and 1992 spring seasons.

	1991			1992			1991 and 1992		
Analyte	Total	High[a]	Low[b]	Total	High[a]	Low[b]	Total	High	Low
Organophosphate Screen									
Azinphos methyl[c]	0			9	0	0	9	0	0
Azinphos methyl OA[c]	0			5	2	0	5	2	0
Chlorpyrifos	9	0	0	10	2	0	19	2	0
Chlorpyrifos OA	8	1	0	7	0	0	15	1	0
DDVP[c]	0			10	0	0	10	0	0
Diazinon	9	1	0	9	0	0	18	1	0
Diazinon OA	9	0	0	8	0	0	17	0	0
Dimethoate[c]	0			10	0	0	10	0	0
Ethyl Parathion[c]	0			9	0	4	9	0	4
Ethyl Parathion OA[c]	0			7	0	0	7	0	0
Malathion	9	0	0	10	1	0	19	1	0
Malathion OA	9	0	0	8	0	0	17	0	0
Methidathion[c]	0			10	0	0	10	0	0
Methidathion OA[c]	0			7	2	0	7	2	0
Methyl Parathion[c]	0			10	0	0	10	0	0
Methyl Parathion OA[c]	0			7	0	0	7	0	0
Phorate[c]	0			7	0	0	7	0	0
Phosalone[c]	0			9	0	0	9	0	0
Phosalone OA[c]	0			7	0	0	7	0	0
Phosmet	9	0	0	10	0	0	19	0	0
Phosmet OA	9	0	0	7	0	0	16	0	0
TOTAL	71	2	0	176	7	4	247	9	4
Carbamate Screen									
Aldicarb	10	3	1	11	0	0	21	3	1
Aldicarb sulfoxide[c]	0			10	1	0	10	1	0
Aldicarb sulfone[c]	0			10	0	1	10	0	1
Carbaryl[c]	0			10	0	0	10	0	0
Carbofuran	10	0	0	11	0	2	21	0	2
Carbofuran 3-Hydroxy[c]	0			11	0	1	11	0	1
Methiocarb	10	0	2	11	0	0	21	0	2
Methomyl[c]	0			11	0	0	11	0	0
Oxamyl	10	4	0	10	0	0	20	4	0
TOTAL	40	7	3	95	1	4	135	8	7
Endosulfan Screen									
Diazinon[c]	0			16	2	0	16	2	0
Diazinon OA[c]	0			16	0	0	16	0	0
Endosulfan I	13	1	0	17	0	0	30	1	0
Endosulfan II	13	0	0	17	0	0	30	0	0
Endosulfan sulfate	13	0	0	17	0	0	30	0	0
TOTAL	39	1	0	83	2	0	122	3	0

a. Continuing quality control sample result was above the upper control limit (see Appendices I and II).

b. Continuing quality control sample result was below the lower control limit (see Appendices I and II).

c. Analyte not analyzed in the 1991 spring season.

Table 8. Acute water quality objectives and criteria for the protection of freshwater aquatic life.

Constituent	CVRWQCB Objectives[a]	U.S. EPA Criteria[b]	CDFG Suggested Criteria[c]
pH	6.5 - 8.5	6.5 - 9.0	NA[d]
Dissolved Oxygen[e]	5.0 mg/L (warm) 7.0 mg/L (cold) 7.0 mg/L (spwn)	3.0 mg/L (warm) 5.0 mg/L (warm, early life stage) 4.0 mg/L (cold) 8.0 mg/L (cold, early life stage)	NA
Electrical Conductivity	NA	NA	NA
Total Ammonia[f]	NA	0.009 - 35 mg/L	NA
Chlorpyrifos	NA	0.083 µg/L	NA[g]
Diazinon	NA	NA	0.08 µg/L
Dimethoate	NA	NA	NA
Methidathion	NA	NA	NA[h]
Carbaryl	NA	NA	2.5 µg/L
Carbofuran	NA	NA	NA[h]
Oxamyl	NA	NA	NA
Endosulfan (Total)	NA	0.22 µg/L	NA

a. Objectives are from: Central Valley Regional Water Quality Control Board. 1994. Water Quality Control Plan (Basin Plan), Central Valley Region, Sacramento and San Joaquin River Basins. Third Edition. Sacramento, CA

b. Criteria are from: United States Environmental Protection Agency. 1986. Quality criteria for water 1986, and Quality criteria for water 1986, Update #2. EPA 440/5-86-001.

c. California Department of Fish and Game's suggested criteria, see Menconi and Cox, 1994, for diazinon and Siepmann and Jones, 1998, for carbaryl.

d. Not available.

e. Dissolved oxygen objectives and criteria are dependent on habitat type (warm, cold, or spawning habitat).

f. Total ammonia criteria are dependent on temperature and pH and therefore have a wide range in values.

g. The suggested criterion in CDFG's chlorpyrifos hazard assessment (Menconi and Paul, 1994) was a combined fresh and salt water value. In discussions among staff from CVRWQCB, DPR, and CDFG, it was decided that CDFG would develop a separate fresh water criterion, in accordance with U.S. EPA methods.

h. Due to a lack of data, CDFG could not develop criteria for methidathion and carbofuran using accepted U.S. EPA methods (Menconi and Siepmann, 1996).

Table 9. Temporal variation in insecticide concentrations (µg/L) in water collected from the San Joaquin River at Laird Park (site 12) during the 1991 and 1992 spring seasons.

			Endosulfan[a]		
Date	Organophosphates[a]	Carbamates[a]	I	II	sulfate
03-04-91	ND[b]	NA[c]	ND	0.005	0.011
03-07-91	ND	ND	ND	ND	ND
03-11-91	ND	ND	ND	ND	ND
03-14-91	ND	ND	ND	ND	ND
03-18-91	Chlorpyrifos 0.05 Malathion 0.06	Carbofuran 0.070	ND	ND	ND
03-21-91	ND	Carbofuran 0.10, d	ND	ND	0.010
03-25-91	ND	Carbofuran 0.10	ND	ND	ND
03-28-91	ND	ND	ND	ND	ND
04-01-91	Malathion 0.05	ND	ND	ND	ND
04-04-91	See Lagrangian survey results in Table 9.				
04-08-91	ND, ND	ND	ND	ND	ND
04-11-91	ND, ND	NA	ND	ND	0.005
04-15-91	ND	ND	ND	ND	0.024
04-18-91	ND	ND, e	ND	ND	0.012
04-22-91	ND	ND	ND	ND	0.019
04-25-91	See Lagrangian survey results in Table 9.				
03-02-92	Diazinon 0.05	ND	ND	ND	ND
03-05-92	ND	ND	ND	ND	ND
03-09-92	Methidathion 0.08	ND	ND	ND	ND
Rinse[f]	ND	NA	NA	NA	NA
03-12-92	Diazinon 0.06	ND	ND	ND	ND
03-16-92	Diazinon 0.10 Malathion 0.08, g	ND	ND	ND	ND

Table 9. Temporal variation in insecticide concentrations (µg/L) in water collected from the San Joaquin River at Laird Park (site 12) during the 1991 and 1992 spring seasons.

03-19-92	Diazinon 0.09	ND	ND	ND	ND
03-23-92	Diazinon 0.09	ND	0.008	ND	0.026
03-26-92	Diazinon 0.05	ND, h, i, j	ND	ND	ND
03-30-92	ND	ND, h, i, j	ND	ND	ND
04-02-92	Diazinon 0.06	ND	ND	ND	ND
04-06-92	ND	ND	ND	ND	ND
04-09-92	ND	ND	ND	ND	ND
04-13-92	ND	ND	ND	ND	ND
04-16-92	See Lagrangian survey results in Table 9.				
04-20-92	ND	ND	ND	ND	ND
04-23-92	ND	ND	ND	ND	ND
04-27-92	ND, g	ND, i	ND	ND	ND
04-30-92	ND	ND	ND	ND	ND
05-04-92	ND	ND	ND	ND	ND

a. All pesticides in the organophosphate and carbamate screens are listed in Table 2. Diazinon and diazinon oxon were analyzed in the endosulfan sample. See text for explanation.
b. ND = none detected. Method detection limits are listed in Table 2.
c. NA = not analyzed.
d. Companion quality control spike was low for methiocarb.
e. Companion quality control spike was low for aldicarb.
f. Equipment rinse water was analyzed to assure cross contamination did not occur between sampling sites.
g. Companion quality control spike was low for ethyl parathion.
h. Companion quality control spike was low for aldicarb sulfone.
i. Companion quality control spike was low for carbofuran.
j. Companion quality control spike was low for 3-Hydroxy carbofuran.

Table 10. Concentrations (µg/L) of organophosphates, carbamates, and endosulfan in water collected during the Lagrangian surveys conducted in the spring of 1991 and 1992.

Date	Site	Organophosphates[a]	Carbamates[a]	Endosulfan[a] I	Endosulfan[a] II	Endosulfan[a] sulfate
04-02-91	1	ND[b]	ND, ND[c]	ND	ND	ND
04-02-91	2	ND	Carbofuran 0.06, 0.05	ND	ND	ND
04-02-91	18	ND	Carbofuran 0.10, 0.11	ND	ND	ND
04-02-91	3	ND	ND, ND	ND	ND	ND
04-02-91	4	ND	ND, ND	ND	ND	ND
04-02-91	5	ND	Carbofuran 0.10, ND	ND	ND	ND
04-03-91	6	ND	ND, ND	ND	ND	ND
04-03-91	7	ND	ND, ND	ND	ND	ND
04-03-91	Rinse[d]	ND	ND	ND	ND	ND
04-03-91	8	No water in Orestimba Creek at time of sampling				
04-03-91	9	ND	ND, ND	ND	ND	ND
04-03-91	Rinse	ND	ND	ND	ND	ND
04-04-91	10	ND	Carbofuran 0.05, ND	ND	ND	ND
04-04-91	11	ND	Carbofuran 0.23, 0.17	ND	ND	0.025
04-04-91	12	ND	Carbofuran 0.05	ND	ND	ND
04-04-91	13	ND	ND, ND	ND	ND	ND
04-04-91	14	ND	ND, ND	0.012	0.023	0.18
04-04-91	15	ND	ND, ND	ND	ND	ND
04-04-91	16	ND	ND, ND	ND	ND	ND
04-04-91	17	ND	ND, ND	ND	ND	0.007
04-23-91	1	ND	ND	ND	ND	ND
04-23-91	2	ND	Oxamyl 0.14	ND	ND	ND
04-23-91	18	ND	Oxamyl 0.12	ND	ND	0.012
04-23-91	3	ND	ND	ND	ND	ND
04-23-91	4	ND	ND, ND	ND	ND	0.006
04-24-91	5	ND	ND	ND	ND	0.021

Table 10. Concentrations (µg/L) of organophosphates, carbamates, and endosulfan in water collected during the Lagrangian surveys conducted in the spring of 1991 and 1992.

Date	Site	Organophosphates[a]	Carbamates[a]	Endosulfan[a]		
				I	II	sulfate
04-24-91	6	ND	ND, ND	ND	ND	ND
04-24-91	7	ND	Oxamyl 0.12	ND	ND	0.007
04-24-91	8	ND	ND	ND	ND	0.039
04-24-91	Rinse	ND	ND	ND	ND	ND
04-25-91	9	Chlorpyrifos 0.23	ND, ND	ND	ND	ND
04-25-91	10	Chlorpyrifos 0.08	ND, ND	ND	ND	0.009
04-25-91	11	ND	ND, ND	ND	ND	0.051
04-25-91	Rinse	ND	ND	ND	ND	ND
04-25-91	12	Chlorpyrifos 0.05	ND	ND	ND	0.012
04-25-91	13	ND	ND, ND	ND	ND	ND
04-26-91	14	ND	Carbofuran 0.05, ND	0.022	0.045	0.20
04-26-91	15	ND	ND, ND,e	NA[f]	NA	NA
04-26-91	16	ND	ND, ND	ND	ND	ND
04-26-91	17	ND	ND, ND, e	NA	NA	NA
04-26-91	Rinse	ND	ND	NA	NA	NA
04-14-92	1	ND, g	ND	ND	ND	ND
04-14-92	2	Diazinon 0.06	Oxamyl 0.27	ND	ND	ND
04-14-92	18	ND, g	Oxamyl 0.15	ND	ND	ND
04-14-92	3	ND	ND	ND	ND	ND
04-14-92	4	ND,g	ND	ND	ND	ND
04-15-92	5	Dimethoate 2.2, 2.0, g	ND	ND	ND	ND
04-15-92	6	ND, g	ND	ND	ND	ND
04-15-92	Rinse	ND	ND	ND	ND	ND
04-15-92	7	ND, g	Oxamyl 0.07	ND	ND	ND
04-15-92	8	Diazinon 0.52, 0.44	ND	ND	ND	ND
04-15-92	9	ND	Carbofuran 0.25	ND	ND	ND

Table 10. Concentrations (µg/L) of organophosphates, carbamates, and endosulfan in water collected during the Lagrangian surveys conducted in the spring of 1991 and 1992.

Date	Site	Organophosphates[a]	Carbamates[a]	Endosulfan[a] I	Endosulfan[a] II	Endosulfan[a] sulfate
04-16-92	10	ND	Carbofuran 0.11 Oxamyl 0.07	ND	ND	ND
04-16-92	11	ND	Carbofuran 0.60 Oxamyl 0.05	ND	ND	ND
04-16-92	12	ND	Carbofuran 0.12 Oxamyl 0.05	ND	ND	ND
04-16-92	Rinse	ND	ND	ND	ND	ND
04-16-92	13	ND	ND	ND	ND	ND
04-16-92	14	Dimethoate 0.18	Carbaryl 0.44, 0.36	ND	ND	0.020
04-16-92	15	ND	Carbofuran 0.08	ND	ND	ND
04-16-92	16	ND	ND	ND	ND	ND
04-17-92	17	ND	ND	ND	ND	ND

a. All pesticides in the organophosphate, carbamate, and endosulfan screens are listed in Table 2. Diazinon and diazinon oxon were analyzed with endosulfan. See text for explanation.
b. ND = none detected. Method detection limits are listed in Table 2.
c. A split sample was analyzed where two values appear.
d. Equipment rinse water was analyzed to assure cross contamination did not occur between sampling sites.
e. Companion quality control spike was low for methiocarb.
f. NA = not analyzed.
g. Companion quality control spike was low for ethyl parathion.

Table 11. Physical and chemical properties of chlorpyrifos, diazinon, oxamyl, carbofuran, and endosulfan. Properties from the Department of Pesticide Regulation Pesticide Chemistry Database (Kollman and Segawa, 1995), or otherwise noted.

Property	Chlorpyrifos	Diazinon	Oxamyl	Carbofuran	Endosulfan
Solubility (mg/L)	1.39 (25°C)	60.0 (22°C)	2.82×10^{5} (25°C)	351 (25°C)	0.32 (22°C)
Hydrolysis Half-life at pH 7 (days)	72.1 (25°C)	138 (24°C)	8.0 (25°C)	10.5[a]	14.8[b] 11 - 19[c]
Aerobic Soil Metabolism Half-life (days)	113[b] 57 - 179[c]	39.7	10.7	22	31.6[b] 26 - 38[c]
Soil Adsorption (K_d)	125[b] 69 - 253[c]	14.6	0.15[b] 0.005-0.31[c]		228[b] 63 - 523
Field Dissipation Half-life (days)	45.0[b] 33 - 56[c] 15[d]	14.2[b] 7 - 30[c] 6[d]	55	30.4[b] 13 - 48[c]	87.6[b] 77 - 93[c]

a. Data from Aly and El-Dib, 1971
b. Mean reported in Kollman and Segawa, 1995.
c. Range reported in Kollman and Segawa, 1995.
d. Data from Ross, et al., 1997.

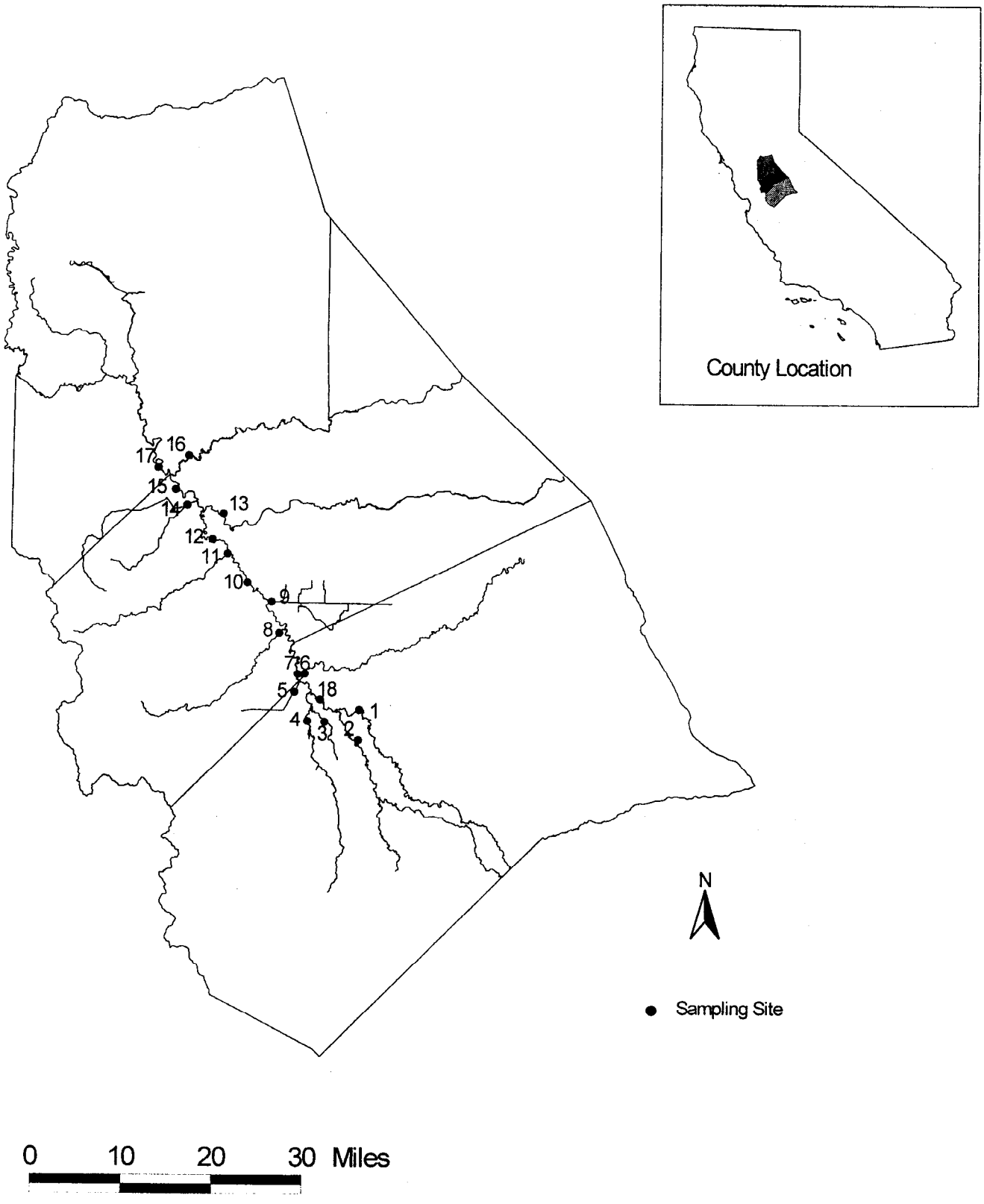

Figure 1. Sampling site locations in the San Joaquin River study area. See Table 1 for site names.

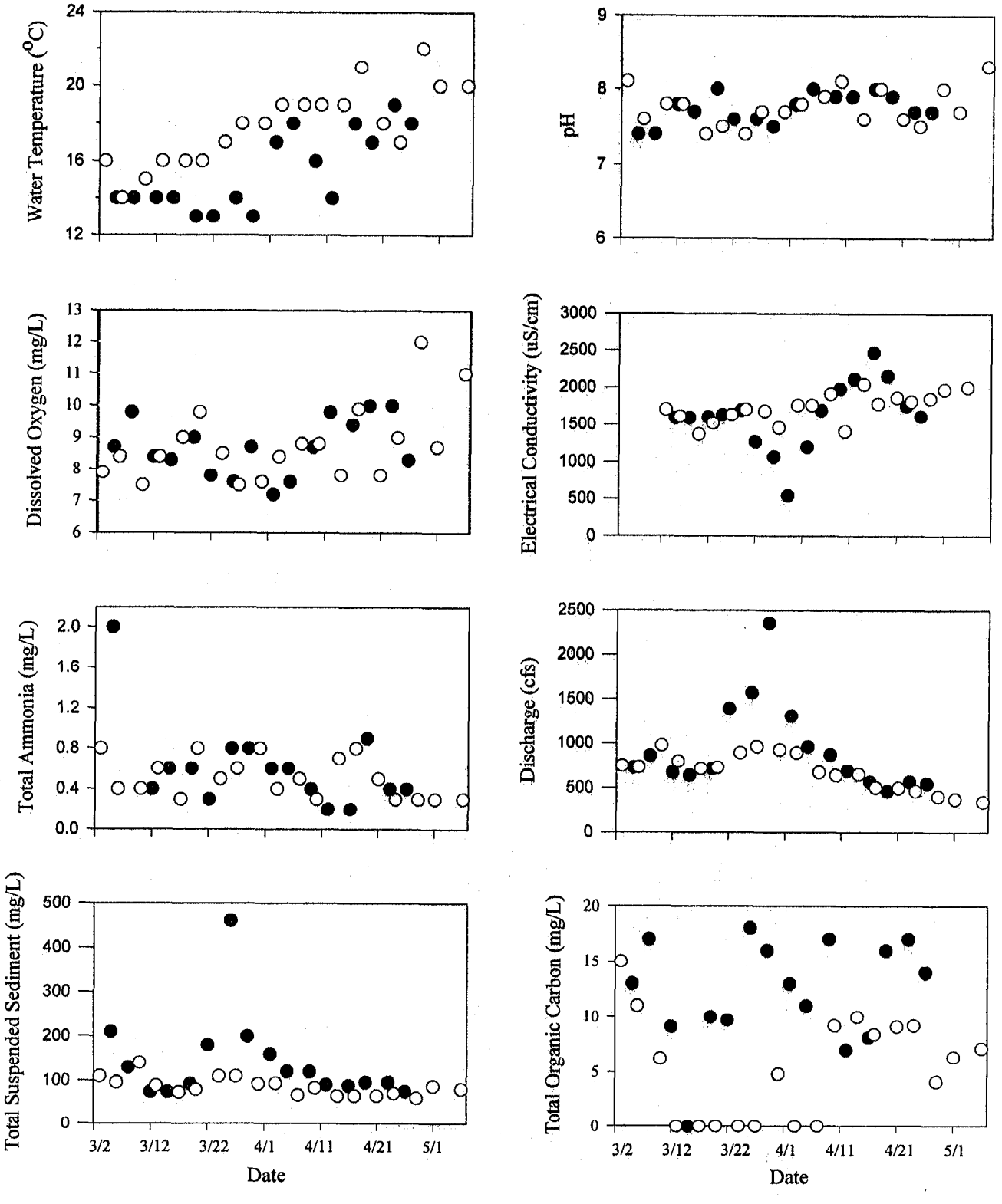

Figure 2. Water quality measurements made in the San Joaquin River at Laird Park during the 1991 and 1992 spring seasons. ● Spring 1991 ○ Spring 1992

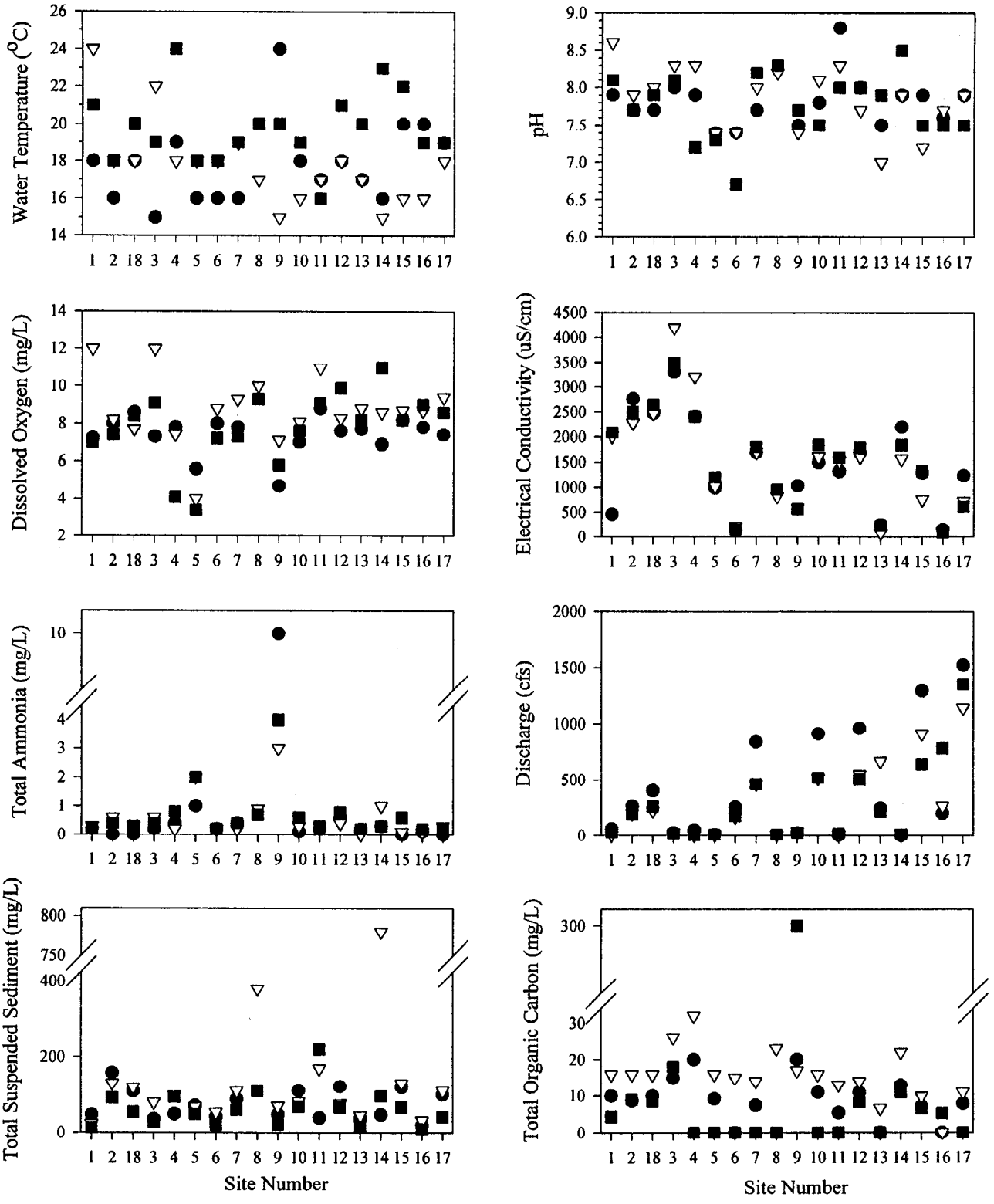

Figure 3. Water quality measurements made during the three Lagrangian surveys conducted in the 1991 and 1992 spring seasons.

● April 2-4, 1991 ▽ April 23-26, 1991 ■ April 14-17, 1992

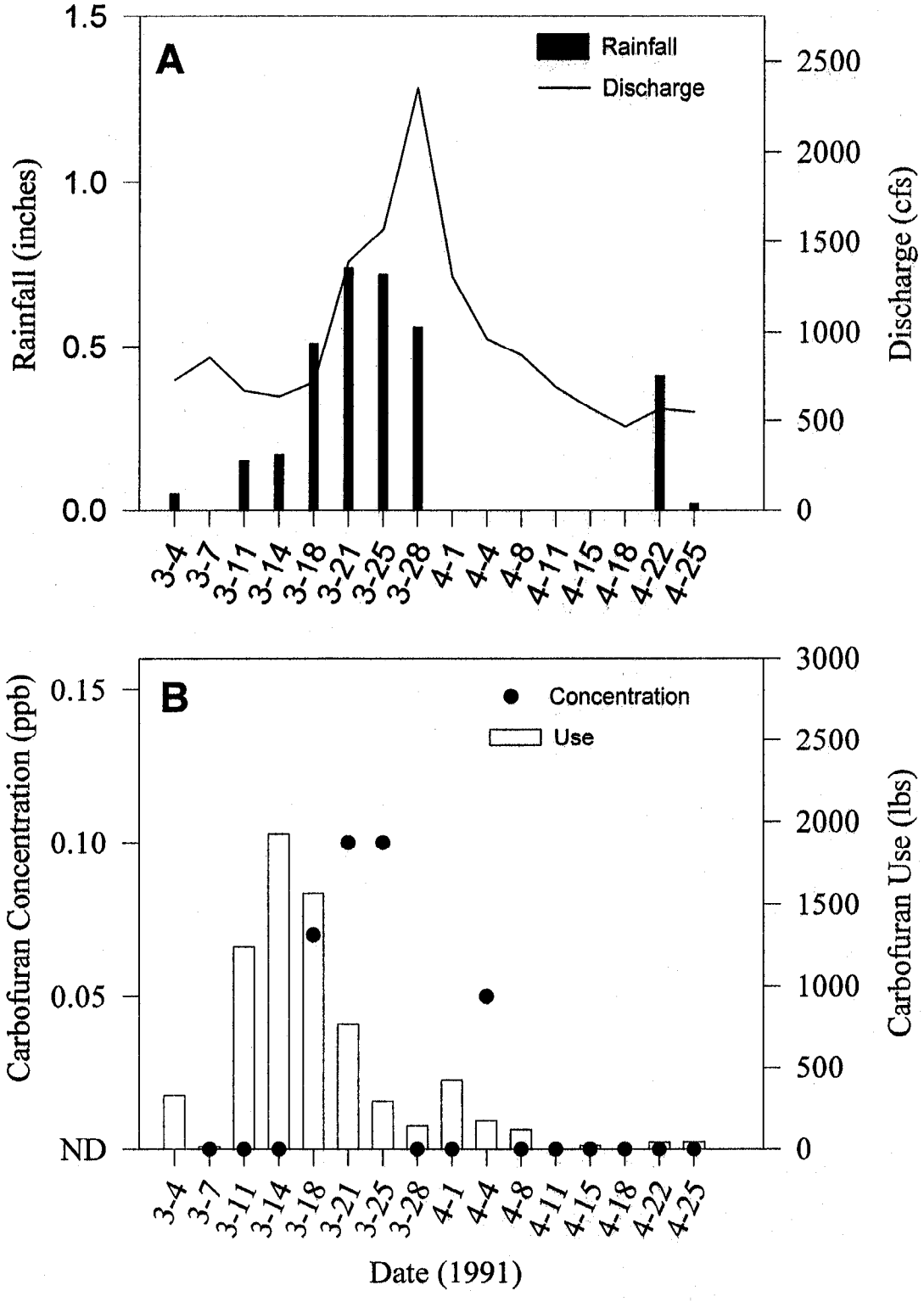

Figure 4. Data collected during the 1991 spring season. (A) Rainfall recorded at Modesto and discharge measured at Laird Park (site 12). (B) Carbofuran concentrations from Laird Park and use reported in Merced and Stanislaus counties. Rainfall and carbofuran use are summed between sampling intervals.

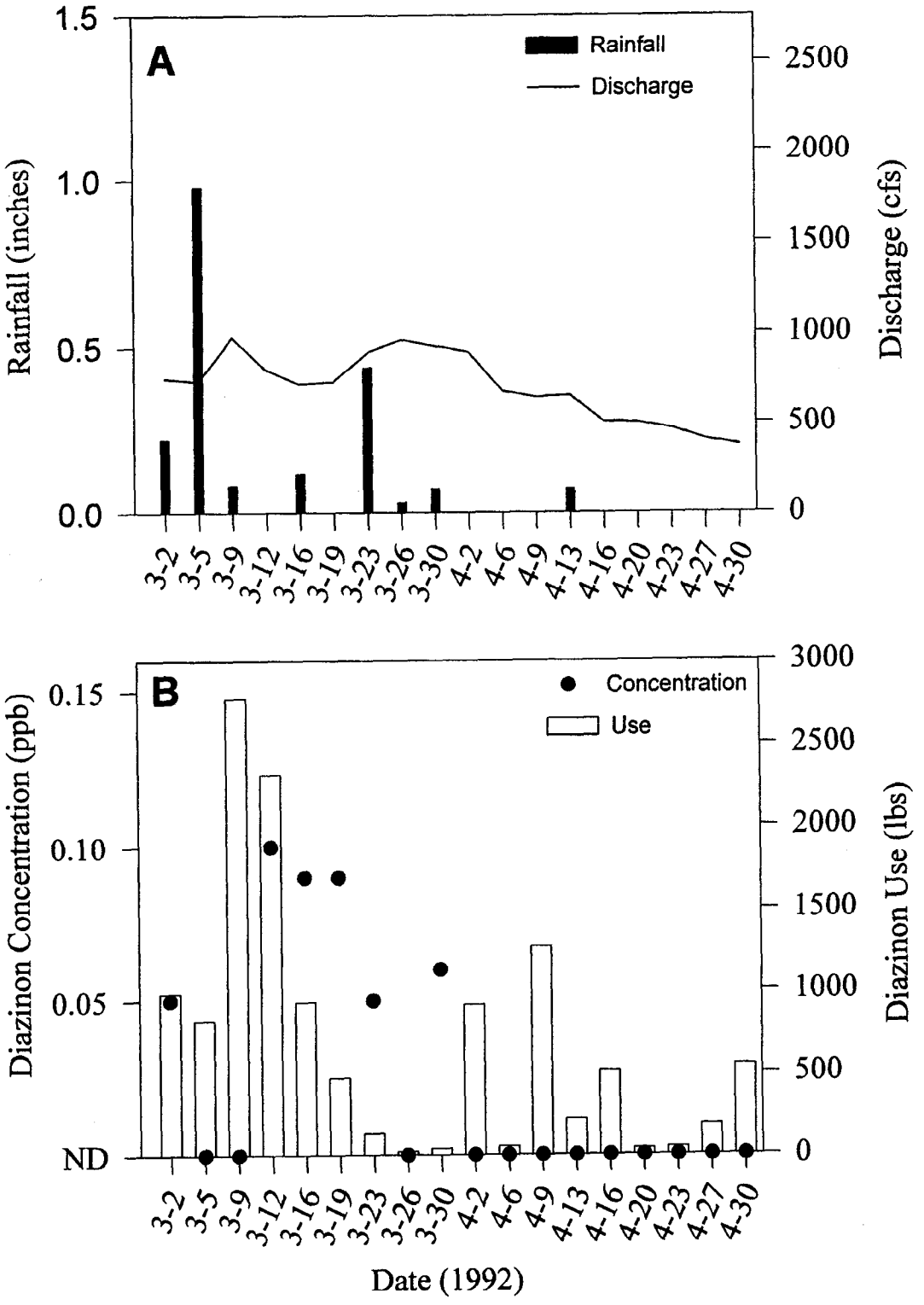

Figure 5. Data collected during the 1992 spring season. (A) Rainfall recorded at Modesto and discharge measured at Laird Park (site 12). (B) Diazinon concentrations from Laird Park and use reported in Merced and Stanislaus counties. Rainfall and diazinon use are summed between sampling intervals.

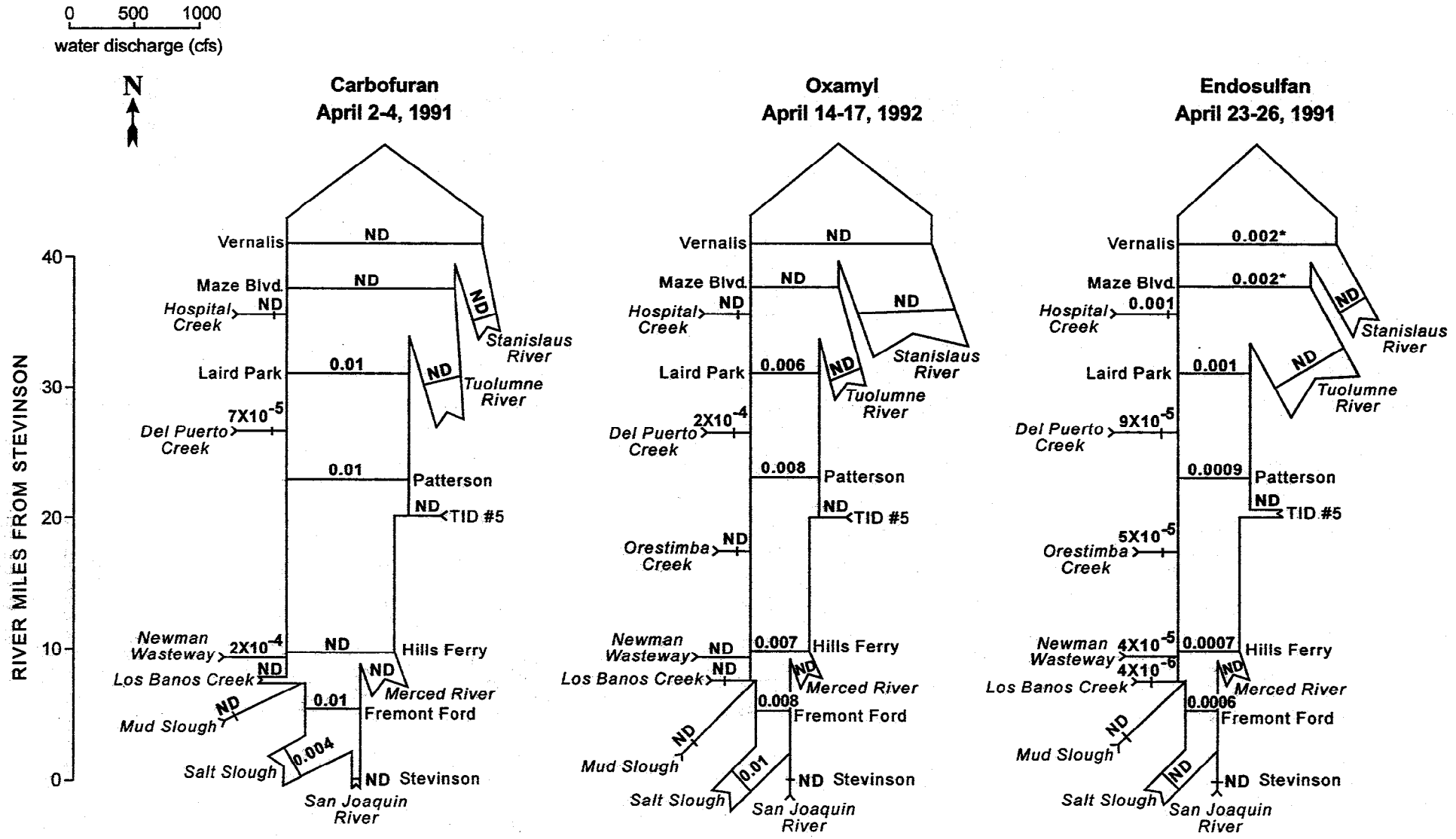

Figure 6. Insecticide loads (lbs/hour) in the San Joaquin River. Water flow is from south to north.

*Mass load estimated from respective tributaries.

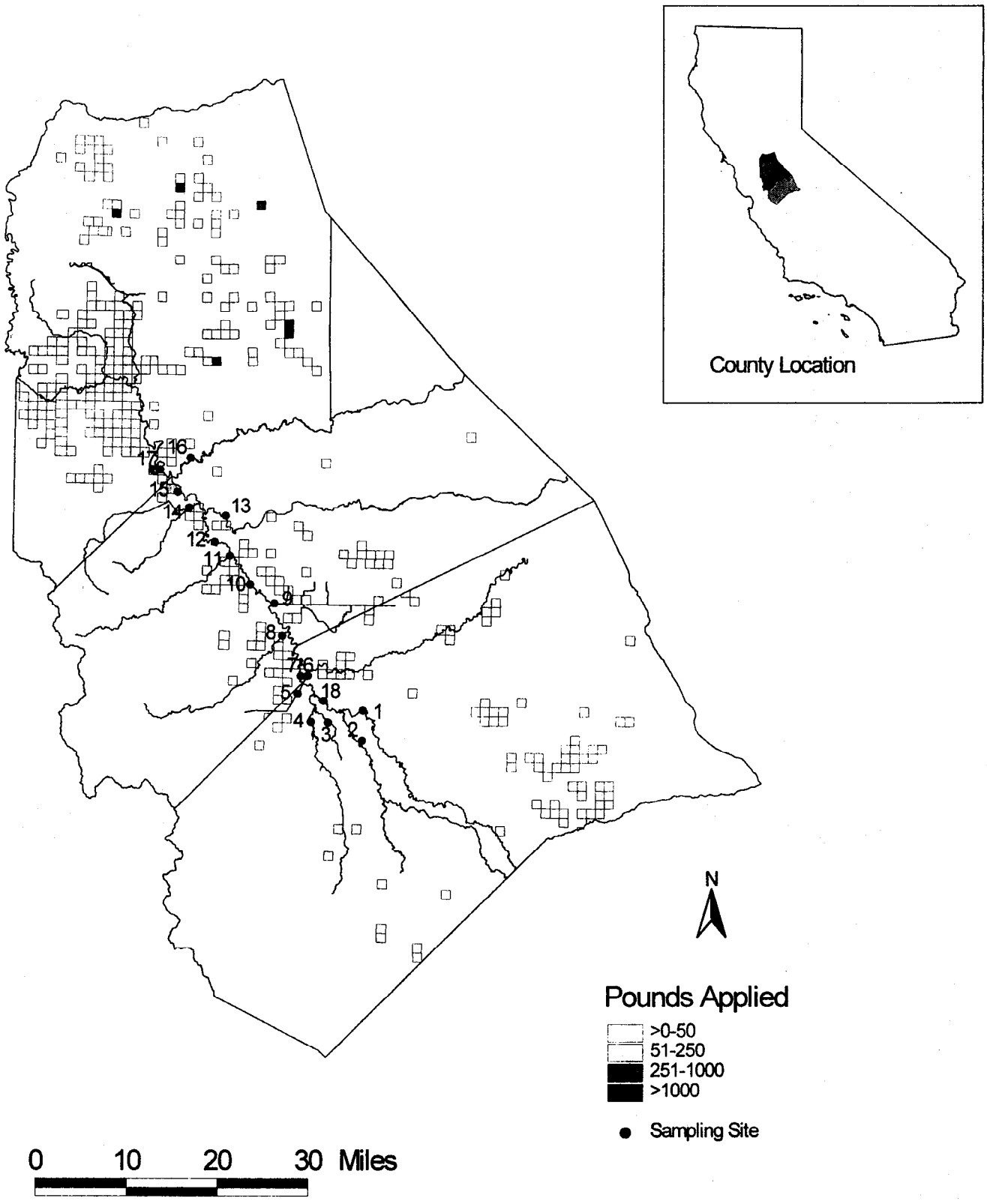

Figure 7. Carbofuran use during January, February, March, and April of 1991.

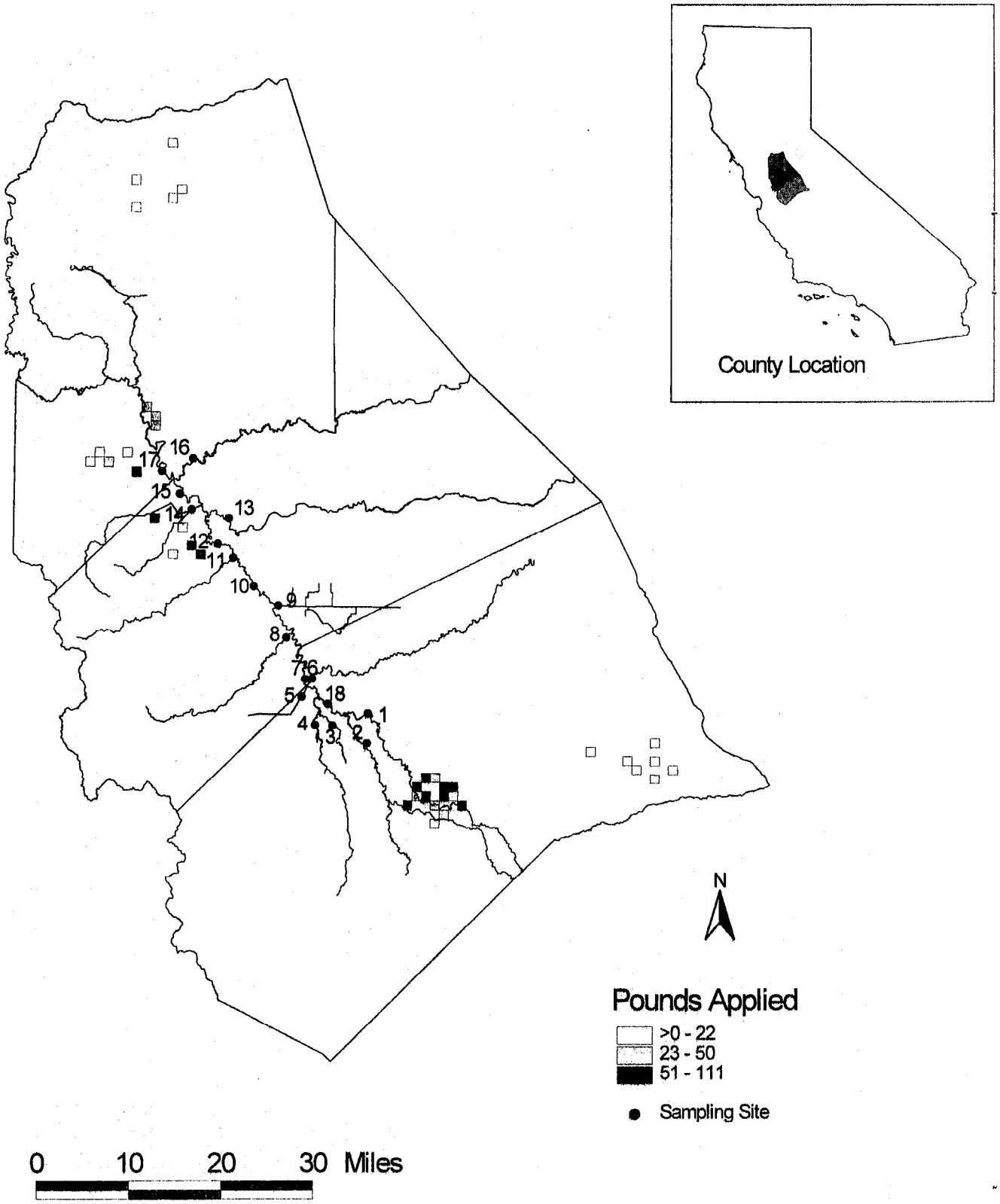

Figure 8. Oxamyl use during January, February, March, and April of 1992.

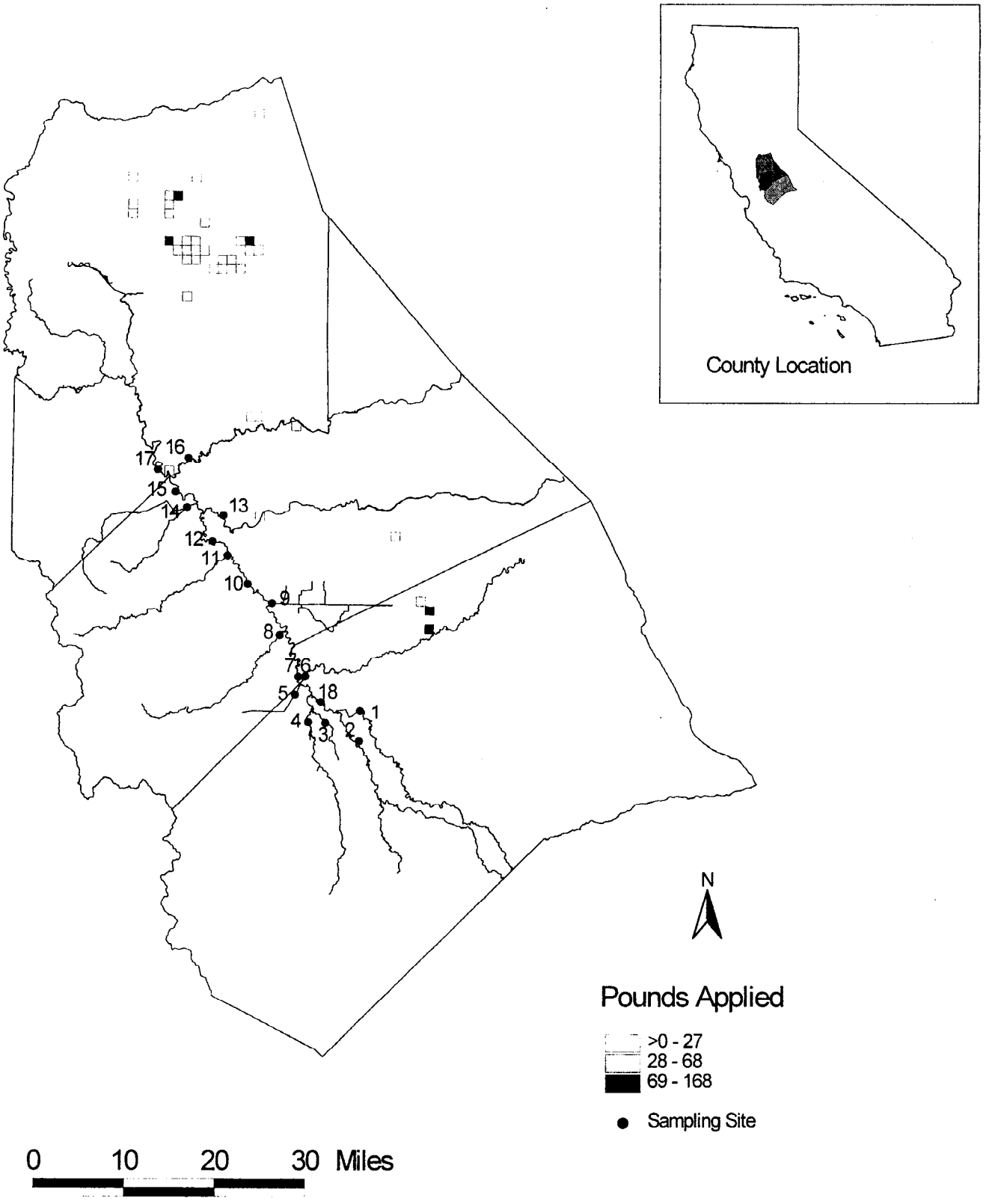

Figure 9. Endosulfan use during January, February, March, and April of 1991.

APPENDIX I. CONTINUING QUALITY CONTROL

Table 1. Continuing quality control data (% recoveries) for the Spring 1991 San Joaquin River study.			
Screen: Organophosphate	UCL = 116		Sample Type: Surface Water
Analyte: Chlorpyrifos	UWL = 110		Lab: CDFA
MDL: 0.05 ppb	LWL = 83		Chemist: Jean Hsu
	LCL = 76		
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %
2, 17, 149, 161, 143	0.5	0.47	94
35, 89, 125, 131, 191, 197, 275, 281	0.5	0.47	94
83, 95, 107, 113, 179, 251, 53, 59, 209	0.5	0.45	90
496, 97	0.5	0.49	98
101, 253, 493	0.5	0.50	100
73	0.5	0.46	92
133, 313, 325, 391, 451, 529, 535, 571	0.5	0.47	94
217, 541, 307, 319, 421, 427, 439, 445, 511, 517, 547, 553, 589	0.5	0.48	96
11, 71, 102, 167, 173, 379, 385, 433	0.5	0.50	100
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			

Table 2. Continuing quality control data (% recoveries) for the Spring 1991 San Joaquin River study.			
Screen: Organophosphate	UCL = 121		Sample Type: Surface Water
Analyte: Chorpyrifos OA	UWL = 113		Lab: CDFA
MDL: 0.1 ppb	LWL = 80		Chemist: Jean Hsu
	LCL = 72		
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %
35, 89, 125, 131, 191, 197, 275, 281	0.5	0.47	94
83, 95, 107, 113, 179, 251, 53, 59, 209	0.5	0.52	104
496, 97	0.5	0.46	92
101, 253, 493	0.5	0.50	100
73	0.5	0.51	102
133, 313, 325, 391, 451, 529, 535, 571	0.5	0.87	174**
217, 541, 307, 319, 421, 427, 439, 445, 511, 517, 547, 553, 589	0.5	0.44	88
11, 71, 102, 167, 173, 379, 385, 433	0.5	0.44	88
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			
** Matrix spike recovery fell above the upper control limit.			

Table 3. Continuing quality control data (% recoveries) for the Spring 1991 San Joaquin River study.			
Screen: Organophosphate	UCL = 122		Sample Type: Surface Water
Analyte: Diazinon	UWL = 113		Lab: CDFA
MDL: 0.05 ppb	LWL = 78		Chemist: Jean Hsu
	LCL = 69		
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %
2, 17, 149, 161, 143	0.5	0.48	96
35, 89, 125, 131, 191, 197, 275, 281	0.5	0.46	92
83, 95, 107, 113, 179, 251, 53, 59, 209	0.5	0.45	90
496, 97	0.5	0.62	124**
101, 253, 493	0.5	0.51	102
73	0.05	0.05	100
133, 313, 325, 391, 451, 529, 535, 571	0.5	0.45	90
217, 541, 307, 319, 421, 427, 439, 445, 511, 517, 547, 553, 589	0.5	0.50	100
11, 71, 102, 167, 173, 379, 385, 433	0.5	0.50	100
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			
** Matrix spike recovery fell above the upper control limit.			

Table 4. Continuing quality control data (% recoveries) for the Spring 1991 San Joaquin River study.

Screen: Organophosphate	UCL = 119		Sample Type: Surface Water	
Analyte: Diazinon OA	UWL = 112		Lab: CDFA	
MDL: 0.1 ppb	LWL = 83		Chemist: Jean Hsu	
	LCL = 76			
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %	
2, 17, 149, 161, 143		0.47	0.5	106
35, 89, 125, 131, 191, 197, 275, 281		0.42	0.5	119
83, 95, 107, 113, 179, 251, 53, 59, 209		0.49	0.5	102
496, 97		0.45	0.5	111
101, 253, 493		0.45	0.5	111
73		0.47	0.5	106
133, 313, 325, 391, 451, 529, 535, 571		0.42	0.5	119
217, 541, 307, 319, 421, 427, 439, 445, 511, 517, 547, 553, 589		0.46	0.5	109
11, 71, 102, 167, 173, 379, 385, 433		0.50	0.5	100

UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.

Table 5. Continuing quality control data (% recoveries) for the Spring 1991 San Joaquin River study.

Screen: Organophosphate	UCL = 114		Sample Type: Surface Water	
Analyte: Malathion	UWL = 109		Lab: CDFA	
MDL: 0.05 ppb	LWL = 87		Chemist: Jean Hsu	
	LCL = 81			
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %	
2, 17, 149, 161, 143	0.5	0.50	100	
35, 89, 125, 131, 191, 197, 275, 281	0.5	0.50	100	
83, 95, 107, 113, 179, 251, 53, 59, 209	0.5	0.44	88	
496, 97	0.5	0.46	92	
101, 253, 493	0.5	0.49	98	
73	0.5	0.47	94	
133, 313, 325, 391, 451, 529, 535, 571	0.5	0.49	98	
217, 541, 307, 319, 421, 427, 439, 445, 511, 517, 547, 553, 589	0.5	0.49	98	
11, 71, 102, 167, 173, 379, 385, 433	0.5	0.54	108	

UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.

Table 6. Continuing quality control data (% recoveries) for the Spring 1991 San Joaquin River study.

Screen: Organophosphate	UCL = 124		Sample Type: Surface Water	
Analyte: Malathion OA	UWL = 117		Lab: CDFA	
MDL: 0.1 ppb	LWL = 88		Chemist: Jean Hsu	
	LCL = 80			
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %	
2, 17, 149, 161, 143	0.5	0.49	98	
35, 89, 125, 131, 191, 197, 275, 281	0.5	0.47	94	
83, 95, 107, 113, 179, 251, 53, 59, 209	0.5	0.50	100	
496, 97	0.5	0.47	94	
101, 253, 493	0.5	0.45	90	
73	0.5	0.48	96	
133, 313, 325, 391, 451, 529, 535, 571	0.5	0.46	92	
217, 541, 307, 319, 421, 427, 439, 445, 511, 517, 547, 553, 589	0.5	0.49	98	
11, 71, 102, 167, 173, 379, 385, 433	0.5	0.47	94	

UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.

Table 7. Continuing quality control data (% recoveries) for the Spring 1991 San Joaquin River study.			
Screen: Organophosphate	UCL = 118		Sample Type: Surface Water
Analyte: Phosmet	UWL = 113		Lab: CDFA
MDL: 0.05 ppb	LWL = 95		Chemist: Jean Hsu
	LCL = 90		
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %
2, 17, 149, 161, 143	0.5	0.54	108
35, 89, 125, 131, 191, 197, 275, 281	0.5	0.49	98
83, 95, 107, 113, 179, 251, 53, 59, 209	0.5	0.46	92
496, 97	0.5	0.57	114
101, 253, 493	0.5	0.53	106
73	0.5	0.52	104
133, 313, 325, 391, 451, 529, 535, 571	0.5	0.54	108
217, 541, 307, 319, 421, 427, 439, 445, 511, 517, 547, 553, 589	0.5	0.52	104
11, 71, 102, 167, 173, 379, 385, 433	0.5	0.53	106
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			

Table 8. Continuing quality control data (% recoveries) for the Spring 1991 San Joaquin River study.			
Screen: Organophosphate	UCL = 124		Sample Type: Surface Water
Analyte: Phosmet OA	UWL = 115		Lab: CDFA
MDL: 0.2 ppb	LWL = 79		Chemist: Jean Hsu
	LCL = 70		
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %
2, 17, 149, 161, 143	0.5	0.41	82
35, 89, 125, 131, 191, 197, 275, 281	0.5	0.50	100
83, 95, 107, 113, 179, 251, 53, 59, 209	0.5	0.48	96
496, 97	0.5	0.45	90
101, 253, 493	0.5	0.46	92
73	0.5	0.45	90
133, 313, 325, 391, 451, 529, 535, 571	0.5	0.48	96
217, 541, 307, 319, 421, 427, 439, 445, 511, 517, 547, 553, 589	0.5	0.47	94
11, 71, 102, 167, 173, 379, 385, 433	0.5	0.56	112
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			

Table 1. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.			
Screen: Organophosphate	UCL = 117	Sample Type: Surface Water	
Analyte: Azinphos-methyl	UWL = 111	Lab: CDFA	
MDL: 0.05 ppb	LWL = 87	Chemist: Jean Hsu	
	LCL = 81		
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %
593, 824	0.5	0.54	108
1623	0.5	0.57	114
1581	0.5	0.58	116
1195,1207,1219,1231,1293,1299,1317,1455,1461, 1467, 1473, 1575, 1689	0.5	0.55	110
1237, 1263	0.5	0.57	114
1557, 1599	0.5	0.44	88
1539	0.5	0.45	90
1245	0.5	0.56	112
1359	0.5	0.56	112
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			

Table 2. Continuing quality control data (%recoveries) for the Spring 1992 San Joaquin River study.			
Screen: Organophosphate	UCL = 114	Sample Type: Surface Water	
Analyte: Azinophos-Methyl OA	UWL = 108	Lab: CDFA	
MDL: 0.30 ppb	LWL = 84	Chemist: Jean Hsu	
	LCL = 78		
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %
1251	0.5	0.60	120**
1545	0.5	0.59	118**
1587, 1684	0.5	0.48	96
1129, 1353	0.5	0.41	82
1287	0.5	0.41	82
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			
** Matrix spike recovery fell above the upper control limit.			

Table 3. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.			
Screen: Organophosphate	UCL = 116	Sample Type: Surface Water	
Analyte: Chlorpyrifos	UWL = 110	Lab: CDFA	
MDL: 0.05 ppb	LWL = 83	Chemist: Jean Hsu	
	LCL = 76		
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %
593, 824	0.5	0.54	108
1623	0.5	0.50	100
1393	0.5	0.48	96
1581	0.5	0.48	96
1195,1207,1219,1231,1293,1299,1317,1455,1461, 1467, 1473, 1575, 1689	0.5	0.51	102
1237, 1263	0.5	0.60	120**
1557, 1599	0.5	0.56	112
1539	0.5	0.54	108
1245	0.5	0.59	118**
1359	0.5	0.53	106
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			
** Matrix spike recovery fell above the upper control limit.			

Table 4. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.			
Screen: Organophosphate	UCL = 121		Sample Type: Surface Water
Analyte: Chloropyrifos OA	UWL = 113		Lab: CDFA
MDL: 0.05 ppb	LWL = 80		Chemist: Jean Hsu
	LCL = 72		
Sample Analyzed with Each Extraction Set	Spike Level	Results	Recovery
(Sample Number)	(ppb)	(ppb)	%
1251	0.5	0.54	108
1195,1207,1219,1231,1293,1299,1317,1455,1461, 1467, 1473, 1575, 1689	0.5	0.42	84
1545	0.5	0.53	106
1587, 1684	0.5	0.47	94
1129, 1353	0.5	0.46	92
1287	0.5	0.41	82
1281, 1465	0.5	0.50	100
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			

Table 5. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.			
Screen: Organophosphate	UCL = 123		Sample Type: Surface Water
Analyte: DDVP	UWL = 115		Lab: CDFA
MDL: 0.05 ppb	LWL = 82		Chemist: Jean Hsu
	LCL = 73		
Sample Analyzed with Each Extraction Set	Spike Level	Results	Recovery
(Sample Number)	(ppb)	(ppb)	%
593, 824	0.5	0.59	118
1623	0.5	0.43	86
1393	0.5	0.42	84
1581	0.5	0.44	88
1195,1207,1219,1231,1293,1299,1317,1455,1461, 1467, 1473, 1575, 1689	0.5	0.55	110
1237, 1263	0.5	0.50	100
1557, 1599	0.5	0.39	78
1539	0.5	0.50	100
1245	0.5	0.52	104
1359	0.5	0.49	98
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			

Table 6. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.			
Screen: Organophosphate	UCL = 122		Sample Type: Surface Water
Analyte: Diazinon	UWL = 113		Lab: CDFA
MDL: 0.05 ppb	LWL = 78		Chemist: Jean Hsu
	LCL = 69		
Sample Analyzed with Each Extraction Set	Spike Level	Results	Recovery
(Sample Number)	(ppb)	(ppb)	%
1623	0.5	0.49	98
1393	0.5	0.44	88
1581	0.5	0.48	96
1195,1207,1219,1231,1293,1299,1317,1455,1461, 1467, 1473, 1575, 1689	0.5	0.47	94
1237,1263,	0.5	0.50	100
1557,1599,	0.5	0.46	92
1539	0.5	0.47	94
1245	0.5	0.48	96
1359	0.5	0.45	90
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			

Table 7. Continuing quality control data for the Winter 1992 San Joaquin River study.

Screen: Organophosphate	UCL = 119		Sample Type: Surface Water
Analyte: Diazinon OA	UWL = 112		Lab: CDFA
MDL: 0.05 ppb	LWL = 83		Chemist: Jean Hsu
	LCL = 76		

Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %
1557, 1599	0.5	0.51	102
1527	0.5	0.45	90
1201, 1213, 1225, 1257, 1323, 1382, 1388	0.5	0.42	84
1515	0.5	0.47	94
1251	0.5	0.45	90
1341	0.5	0.48	96
1300	0.5	0.49	98
1329	0.5	0.49	98

UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.

Table 8. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.

Screen: Organophosphate	UCL = 116		Sample Type: Surface Water
Analyte: Dimethoate	UWL = 110		Lab: CDFA
MDL: 0.05 ppb	LWL = 86		Chemist: Jean Hsu
	LCL = 80		

Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %
593, 824	0.5	0.52	104
1623	0.5	0.49	98
1393	0.5	0.49	98
1581	0.5	0.51	102
1195,1207,1219,1231,1293,1299,1317,1455,1461, 1467, 1473, 1575, 1689	0.5	0.50	100
1237, 1263	0.5	0.53	106
1557, 1599	0.5	0.47	94
1539	0.5	0.46	92
1245	0.5	0.52	104
1359	0.5	0.50	100

UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.

Table 9. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.

Screen: Organophosphate	UCL = 108		Sample Type: Surface Water
Analyte: E. Parathion	UWL = 104		Lab: CDFA
MDL: 0.05 ppb	LWL = 89		Chemist: Jean Hsu
	LCL = 86		

Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %
593, 824	0.5	0.43	86
1557, 1599	0.5	0.50	100
1527	0.5	0.42	84*
1201, 1213, 1225, 1257, 1323, 1382, 1388	0.5	0.42	84*
1515	0.5	0.46	92
1251	0.5	0.41	82*
1341	0.5	0.44	88
1300	0.5	0.46	92
1329	0.5	0.46	92

UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.

* Matrix spike recovery fell below the lower control limit.

Table 10. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.			
Screen: Organophosphate	UCL = 113		Sample Type: Surface Water
Analyte: Ethyl Paraoxon	UWL = 107		Lab: CDFA
MDL: 0.05 ppb	LWL = 83		Chemist: Jean Hsu
	LCL = 77		
Sample Analyzed with Each Extraction Set	Spike Level	Results	Recovery
(Sample Number)	(ppb)	(ppb)	%
1251	0.5	0.45	90
1195,1207,1219,1231,1293,1299,1317,1455,1461, 1467, 1473, 1575, 1689	0.5	0.46	92
1545	0.5	0.47	94
1587, 1684	0.5	0.51	102
1129, 1353	0.5	0.48	96
1287	0.5	0.46	92
1281, 1465	0.5	0.49	98
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			

Table 11. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.			
Screen: Organophosphate	UCL = 114		Sample Type: Surface Water
Analyte: Malathion	UWL = 109		Lab: CDFA
MDL: 0.05 ppb	LWL = 87		Chemist: Jean Hsu
	LCL = 81		
Sample Analyzed with Each Extraction Set	Spike Level	Results	Recovery
(Sample Number)	(ppb)	(ppb)	%
593, 824	0.5	0.52	104
1623	0.5	0.58	116**
1393	0.5	0.50	100
1581	0.5	0.47	94
1195,1207,1219,1231,1293,1299,1317,1455,1461, 1467, 1473, 1575, 1689	0.5	0.54	108
1237, 1263	0.5	0.51	102
1557, 1599	0.5	0.45	90
1539	0.5	0.46	92
1245	0.5	0.50	100
1359	0.5	0.50	100
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			
** Matrix spike recovery fell above the upper control limit.			

Table 12. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.			
Screen: Organophosphate	UCL = 124		Sample Type: Surface Water
Analyte: Malaoxon	UWL = 117		Lab: CDFA
MDL: 0.05 ppb	LWL = 88		Chemist: Jean Hsu
	LCL = 80		
Sample Analyzed with Each Extraction Set	Spike Level	Results	Recovery
(Sample Number)	(ppb)	(ppb)	%
1557, 1599	0.5	0.48	96
1527	0.5	0.57	114
1201, 1213, 1225, 1257, 1323, 1382, 1388	0.5	0.46	92
1515	0.5	0.54	108
1251	0.5	0.46	92
1341	0.5	0.55	110
1300	0.5	0.53	106
1329	0.5	0.55	110
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			

Table 13. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.							
Screen: Organophosphate	UCL = 124		Sample Type: Surface Water				
Analyte: Methidathion	UWL = 116		Lab: CDFA				
MDL: 0.05 ppb	LWL = 83		Chemist: Jean Hsu				
	LCL = 75						
Sample Analyzed with Each Extraction Set	Spike Level	Results	Recovery				
(Sample Number)	(ppb)	(ppb)	%				
593, 824	0.5	0.57	114				
1623	0.5	0.51	102				
1393	0.5	0.49	98				
1581	0.5	0.46	92				
1195,1207,1219,1231,1293,1299,1317,1455,1461, 1467, 1473, 1575, 1689	0.5	0.50	100				
1237, 1263	0.5	0.51	102				
1557, 1599	0.5	0.47	94				
1539	0.5	0.45	90				
1245	0.5	0.50	100				
1359	0.5	0.51	102				
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.							

Table 14. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.							
Screen: Organophosphate	UCL = 117		Sample Type: Surface Water				
Analyte: Methidation OA	UWL = 111		Lab: CDFA				
MDL: 0.05 ppb	LWL = 85		Chemist: Jean Hsu				
	LCL = 78						
Sample Analyzed with Each Extraction Set	Spike Level	Results	Recovery				
(Sample Number)	(ppb)	(ppb)	%				
1251	0.5	0.60	120**				
1195,1207,1219,1231,1293,1299,1317,1455,1461, 1467, 1473, 1575, 1689	0.5	0.42	84				
1545	0.5	0.55	110				
1587, 1684	0.5	0.50	100				
1129, 1353	0.5	0.46	92				
1287	0.5	0.43	86				
1281, 1465	0.5	0.60	120**				
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.							
** Matrix spike recovery fell above the upper control limit.							

Table 15. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.							
Screen: Organophosphate	UCL = 116		Sample Type: Surface Water				
Analyte: Methyl Parathion	UWL = 110		Lab: CDFA				
MDL: 0.05 ppb	LWL = 85		Chemist: Jean Hsu				
	LCL = 79						
Sample Analyzed with Each Extraction Set	Spike Level	Results	Recovery				
(Sample Number)	(ppb)	(ppb)	%				
593, 824	0.5	0.51	102				
1623	0.5	0.50	100				
1393	0.5	0.47	94				
1581	0.5	0.48	96				
1195,1207,1219,1231,1293,1299,1317,1455,1461, 1467, 1473, 1575, 1689	0.5	0.50	100				
1237, 1263	0.5	0.49	98				
1557,1599,	0.5	0.48	96				
1539	0.5	0.47	94				
1245	0.5	0.49	98				
1359	0.5	0.49	98				
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.							

Table 16. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.				
Screen: Organophosphate	UCL = 120		Sample Type: Surface Water	
Analyte: Methyl Paraoxon	UWL = 112		Lab: CDFA	
MDL: 0.05 ppb	LWL = 79		Chemist: Jean Hsu	
	LCL = 71			
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %	
1251	0.5	0.49	98	
1195,1207,1219,1231,1293,1299,1317,1455,1461, 1467, 1473, 1575, 1689	0.5	0.45	90	
1545	0.5	0.50	100	
1587, 1684	0.5	0.50	100	
1129, 1353	0.5	0.55	110	
1287	0.5	0.44	88	
1281, 1465	0.5	0.49	98	
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.				

Table 17. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.				
Screen: Organophosphate	UCL = 110		Sample Type: Surface Water	
Analyte: Phorate	UWL = 104		Lab: CDFA	
MDL: 0.05 ppb	LWL = 80		Chemist: Jean Hsu	
	LCL = 74			
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %	
1251	0.5	0.42	84	
1195,1207,1219,1231,1293,1299,1317,1455,1461, 1467, 1473, 1575, 1689	0.5	0.49	98	
1545	0.5	0.45	89	
1587, 1684	0.5	0.51	102	
1129, 1353	0.5	0.43	86	
1287	0.5	0.49	98	
1281, 1465	0.5	0.50	100	
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.				

Table 18. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.				
Screen: Organophosphate	UCL = 125		Sample Type: Surface Water	
Analyte: Phosalone	UWL = 117		Lab: CDFA	
MDL: 0.05 ppb	LWL = 87		Chemist: Jean Hsu	
	LCL = 79			
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %	
593, 824	0.5	0.44	88	
1557, 1599	0.5	0.50	100	
1527	0.5	0.45	90	
1201,1213,1225,1257,1323,1382, 1388	0.5	0.47	94	
1515	0.5	0.49	98	
1251	0.5	0.43	86	
1341	0.5	0.46	92	
1300	0.5	0.47	94	
1329	0.5	0.48	96	
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.				

Table 19. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.			
Screen: Organophosphate	UCL = 129		Sample Type: Surface Water
Analyte: Phosalone OA	UWL = 121		Lab: CDFA
MDL: 0.05 ppb	LWL = 85		Chemist: Jean Hsu
	LCL = 77		
Sample Analyzed with Each Extraction Set	Spike Level	Results	Recovery
(Sample Number)	(ppb)	(ppb)	%
1557, 1599	0.5	0.50	100
1527	0.5	0.55	110
1201,1213,1225,1257,1323,1382, 1388	0.5	0.54	108
1515	0.5	0.55	110
1251	0.5	0.54	108
1341	0.5	0.59	118
1329	0.5	0.56	112
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			

Table 20. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.			
Screen: Organophosphate	UCL = 118		Sample Type: Surface Water
Analyte: Phosmet	UWL = 113		Lab: CDFA
MDL: 0.05 ppb	LWL = 95		Chemist: Jean Hsu
	LCL = 90		
Sample Analyzed with Each Extraction Set	Spike Level	Results	Recovery
(Sample Number)	(ppb)	(ppb)	%
593, 824	0.5	0.53	106
1623	0.5	0.58	116
1393	0.5	0.58	116
1581	0.5	0.47	94
1195,1207,1219,1231,1293,1299,1317,1455,1461, 1467, 1473, 1575, 1689	0.5	0.54	108
1237, 1263	0.5	0.51	102
1557, 1599	0.5	0.52	104
1539	0.5	0.47	94
1245	0.5	0.51	102
1359	0.5	0.58	116
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			

Table 21. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.			
Screen: Organophosphate	UCL = 124		Sample Type: Surface Water
Analyte: Phosmet OA	UWL = 115		Lab: CDFA
MDL: 0.05 ppb	LWL = 79		Chemist: Jean Hsu
	LCL = 70		
Sample Analyzed with Each Extraction Set	Spike Level	Results	Recovery
(Sample Number)	(ppb)	(ppb)	%
1557, 1599	0.5	0.49	98
1527	0.5	0.56	112
1201,1213,1225,1257,1323,1382, 1388	0.5	0.55	110
1515	0.5	0.54	108
1251	0.5	0.51	102
1341	0.5	0.42	84
1329	0.5	0.59	118
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			

Table 1. Continuing quality control data (% recoveries) for the Spring 1991 San Joaquin River study.				
Screen: Carbamate	UCL = 109		Sample Type: Surface Water	
Analyte: Aldicarb	UWL = 89		Lab: Enseco-Cal	
MDL: 0.1 ppb	LWL = 105		Chemist: Frank Kenney	
	LCL = 85			
Sample Analyzed with Each Extraction Set	Spike Level	Results	Recovery	Mean Recovery
(Sample Number)	(ppb)	(ppb)	%	%
5	0.5	0.46	92	
	0.5	0.45	90	91
8, 26	0.5	0.74	149	
	0.5	0.53	105	127**
158	0.5	0.41	81	
	0.5	0.53	105	93
272, 128, 278, 122, 188, 194, 32, 86	0.5	0.54	108	
	0.5	0.47	94	101
98	0.5	0.58	116	
	0.5	0.44	89	103
153, 164	0.5	0.60	121	
	0.5	0.50	101	111**
254	0.5	0.42	85	
	0.5	0.61	123	104
74	0.5	0.45	91	
	0.5	0.37	73	82*
218, 542	0.5	0.54	108	
	0.5	0.50	100	104
380, 386, 434	0.5	0.50	101	
	0.5	0.59	119	110**
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.				
* Mean spike recovery fell below the lower control limit.				
** Mean spike recovery fell above the upper control limit.				

Table 2. Continuing quality control data (% recoveries) for the Spring 1991 San Joaquin River study.				
Screen: Carbamate	UCL = 113		Sample Type: Surface Water	
Analyte: Carbofuran	UWL = 108		Lab: CDFA	
MDL: 0.05 ppb	LWL = 89		Chemist: Paul Lee	
	LCL = 84			
Sample Analyzed with Each Extraction Set	Spike Level	Results	Recovery	
(Sample Number)	(ppb)	(ppb)	%	
521, 449, 383, 389, 437, 515, 387, 435	1.0	0.90	90	
534, 396, 330, 323, 431, 551, 137, 455, 317	1.0	0.93	93	
540, 545, 525, 557, 443, 311, 221, 381	0.25	0.25	100	
49, 265, 187, 55, 277, 205, 38, 271	0.25	0.27	108	
31, 85, 91, 109, 121, 127, 175, 193	0.25	0.23	92	
79, 103, 211, 247, 552	0.25	0.21	84	
36, 54, 60, 72, 77, 78, 138, 192, 210, 318	0.25	0.23	92	
222, 257, 258, 282, 432, 450, 456, 497, 516, 546	0.25	0.21	84	
12, 18, 96, 126, 132,150, 162, 168, 276, 384	1.0	0.92	92	
84, 90, 114, 144, 174, 198, 252, 312, 438, 444	0.1	0.09	85	
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.				

Table 3. Continuing quality control data (% recoveries) for the Spring 1991 San Joaquin River study.				
Screen: Carbamate	UCL = 110		Sample Type: Surface Water	
Analyte: Methiocarb	UWL = 103		Lab: Enseco-Cal	
MDL: 0.1 ppb	LWL = 79		Chemist: Frank Kenney	
	LCL = 72			
Sample Analyzed with Each Extraction Set	Spike Level	Results	Recovery	Mean Recovery
(Sample Number)	(ppb)	(ppb)	%	%
5	0.5	0.38	76	
	0.5	0.41	82	79
8, 26	0.5	0.50	100	
	0.5	0.58	116	108
158	0.5	0.30	60	
	0.5	0.34	68	64*
272, 128, 278, 122, 188, 194, 32, 86	0.5	0.37	74	
	0.5	0.41	82	78
98	0.5	0.48	96	
	0.5	0.42	84	90
153, 164	0.5	0.44	88	
	0.5	0.46	92	90
254	0.5	0.45	90	
	0.5	0.43	86	88
74	0.5	0.45	90	
	0.5	0.41	82	86
218, 542	0.5	0.52	104	
	0.5	0.46	92	98
380, 386, 434	0.5	0.24	48	
	0.5	0.29	58	53*
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.				
* Mean spike recovery fell below the lower control limit.				

Table 4. Continuing quality control data (% recoveries) for the Spring 1991 San Joaquin River study.				
Screen: Carbamate	UCL = 115		Sample Type: Surface Water	
Analyte: Oxamyl	UWL = 102		Lab: Enseco-Cal	
MDL: 0.1 ppb	LWL = 50		Chemist: Frank Kenney	
	LCL = 37			
Sample Analyzed with Each Extraction Set	Spike Level	Results	Recovery	Mean Recovery
(Sample Number)	(ppb)	(ppb)	%	%
5	0.5	0.32	64	
	0.5	0.30	60	62
8, 26	0.5	0.60	120	
	0.5	0.58	116	118**
158	0.5	0.49	98	
	0.5	0.51	102	100
272, 128, 278, 122, 188, 194, 32, 86	0.5	0.49	98	
	0.5	0.49	98	98
98	0.5	0.61	122	
	0.5	0.67	134	128**
153, 164	0.5	0.70	140	
	0.5	0.73	146	143**
254	0.5	0.73	146	
	0.5	0.56	112	129**
74	0.5	0.39	78	
	0.5	0.49	98	88
218, 542	0.5	0.57	114	
	0.5	0.52	104	109
380, 386, 434	0.5	0.22	44	
	0.5	0.30	60	52
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.				
** Mean spike recovery fell above the upper control limit.				

Table 1. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.			
Screen: Carbamate	UCL = 117		Sample Type: Surface Water
Analyte: Aldicarb	UWL = 109		Lab: CDFA
MDL: 0.05 ppb	LWL = 76		Chemist: S. Richman
	LCL = 68		
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %
1399	0.1	0.095	95
1330 ,1342	0.1	0.087	87
1130 ,1354	0.1	0.079	79
1360	0.1	0.075	75
1246 ,1516 , 1683	0.1	0.081	81
1540 ,1588 ,1685	0.1	0.077	77
1288,1546,1558, 1600	0.1	0.080	80
1202,1214,1226,1238,1258,1264,1324,1383,1389 ,1687, 1688	0.1	0.082	82
1196,1208,1220,1232,1294,1300,1318,1456,1462 ,1468, 1474, 1576	0.1	0.081	81
1282 ,1624	0.1	0.080	80
1528	0.1	0.084	84
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			

Table 2. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.			
Screen: Carbamate	UCL = 87		Sample Type: Surface Water
Analyte: Aldicarb sulfoxide	UWL = 81		Lab: CDFA
MDL: 0.05 ppb	LWL = 57		Chemist: S. Richman
	LCL = 50		
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %
1330 ,1342	0.1	0.066	66
1130 ,1354	0.1	0.070	70
1360	0.1	0.068	68
1246 ,1516 , 1683	0.1	0.068	68
1540 ,1588 ,1685	0.1	0.068	68
1288,1546,1558, 1600	0.1	0.082	82
1202,1214,1226,1238,1258,1264,1324,1383,1389 ,1687, 1688	0.1	0.072	72
1196,1208,1220,1232,1294,1300,1318,1456,1462 ,1468, 1474, 1576	0.1	0.091	91**
1528	0.1	0.075	75
1282 ,1624	0.1	0.072	72
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			
** Matrix spike recovery fell above the upper control limit.			

Table 3. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.			
Screen: Carbamate	UCL = 116		Sample Type: Surface Water
Analyte: Aldicarb sulfone	UWL = 111		Lab: CDFA
MDL: 0.05 ppb	LWL = 88		Chemist: S. Richman
	LCL = 82		
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %
1330 ,1342	0.1	0.109	109
1130 ,1354	0.1	0.087	87
1360	0.1	0.085	85
1246 ,1516 , 1683	0.1	0.091	91
1540 ,1588 ,1685	0.1	0.079	79*
1288,1546,1558, 1600	0.1	0.085	85
1202,1214,1226,1238,1258,1264,1324,1383,1389 ,1687, 1688	0.1	0.084	84
1196,1208,1220,1232,1294,1300,1318,1456,1462 ,1468, 1474, 1576	0.1	0.089	89
1224,1528, 1582	0.1	0.104	104
1282 ,1624	0.1	0.091	91
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			
* Matrix spike recovery fell below the lower control limit.			

Table 4. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.

Screen: Carbamate	UCL = 124		Sample Type: Surface Water
Analyte: Carbaryl	UWL = 116		Lab: CDFA
MDL: 0.05 ppb	LWL = 83		Chemist: S. Richman
	LCL = 75		
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %
1330 ,1342	0.10	0.092	92
1130 ,1354	0.10	0.087	87
1360	0.10	0.083	83
1246 ,1516 , 1683	0.10	0.089	89
1540 ,1588 ,1685	0.10	0.091	91
1288,1546,1558, 1600	0.10	0.089	89
1202,1214,1226,1238,1258,1264,1324,1383,1389 ,1687, 1688	0.10	0.086	86
1196,1208,1220,1232,1294,1300,1318,1456,1462 ,1468, 1474, 1576	0.10	0.094	94
1528	0.10	0.093	93
1282 ,1624	0.10	0.097	97

UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.

Table 5. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.

Screen: Carbamate	UCL = 113		Sample Type: Surface Water
Analyte: Carbofuran	UWL = 108		Lab: CDFA
MDL: 0.05 ppb	LWL = 89		Chemist: S. Richman
	LCL = 84		
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %
1330 ,1342	0.1	0.102	102
1130 ,1354	0.1	0.086	86
1360	0.1	0.087	87
1246 ,1516 , 1683	0.1	0.086	86
1540 ,1588 ,1685	0.1	0.075	75*
1288,1546,1558, 1600	0.1	0.093	93
1202,1214,1226,1238,1258,1264,1324,1383,1389 ,1687, 1688	0.1	0.091	91
1196,1208,1220,1232,1294,1300,1318,1456,1462 ,1468, 1474, 1576	0.1	0.095	95
1528	0.1	0.082	82*
1282 ,1624	0.1	0.086	86
1399	0.1	0.090	90

UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.

* Matrix spike recovery fell below the lower control limit.

Table 6. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.

Screen: Carbamate	UCL = 126		Sample Type: Surface Water
Analyte: 3- Hydroxy carbofuran	UWL = 117		Lab: CDFA
MDL: 0.05 ppb	LWL = 82		Chemist: S. Richman
	LCL = 73		
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %
1330 ,1342	0.1	0.110	110
1130 ,1354	0.1	0.086	86
1360	0.1	0.081	81
1246 ,1516 , 1683	0.1	0.092	92
1540 ,1588 ,1685	0.1	0.071	71*
1288,1546,1558, 1600	0.1	0.096	96
1202,1214,1226,1238,1258,1264,1324,1383,1389 ,1687, 1688	0.1	0.089	89
1196,1208,1220,1232,1294,1300,1318,1456,1462 ,1468, 1474, 1576	0.1	0.097	97
1528	0.1	0.091	91
1282 ,1624	0.1	0.083	83
1399	0.1	0.081	81

UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.

* Matrix spike recovery fell below the lower control limit.

Table 7. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.			
Screen: Carbamate	UCL = 120		Sample Type: Surface Water
Analyte: Methiocarb	UWL = 113		Lab: CDFA
MDL: 0.05 ppb	LWL = 84		Chemist: S. Richman
	LCL = 76		
Sample Analyzed with Each Extraction Set	Spike Level	Results	Recovery
(Sample Number)	(ppb)	(ppb)	%
1330 ,1342	0.1	0.118	118
1130 ,1354	0.1	0.086	86
1360	0.1	0.082	82
1246 ,1516 , 1683	0.1	0.093	93
1540 ,1588 ,1685	0.1	0.079	79
1288,1546,1558, 1600	0.1	0.085	85
1202,1214,1226,1238,1258,1264,1324,1383,1389 ,1687, 1688	0.1	0.088	88
1196,1208,1220,1232,1294,1300,1318,1456,1462 ,1468, 1474, 1576	0.1	0.092	92
1528	0.1	0.088	88
1282 ,1624	0.1	0.087	87
1399	0.1	0.083	83
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			

Table 8. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.			
Screen: Carbamate	UCL = 123		Sample Type: Surface Water
Analyte: Methomyl	UWL = 114		Lab: CDFA
MDL: 0.05 ppb	LWL = 79		Chemist: S. Richman
	LCL = 70		
Sample Analyzed with Each Extraction Set	Spike Level	Results	Recovery
(Sample Number)	(ppb)	(ppb)	%
1330 ,1342	0.1	0.106	106
1130 ,1354	0.1	0.085	85
1360	0.1	0.080	80
1246 ,1516 , 1683	0.1	0.091	91
1540 ,1588 ,1685	0.1	0.071	71
1288,1546,1558, 1600	0.1	0.080	80
1202,1214,1226,1238,1258,1264,1324,1383,1389 ,1687, 1688	0.1	0.087	87
1196,1208,1220,1232,1294,1300,1318,1456,1462 ,1468, 1474, 1576	0.1	0.091	91
1528	0.1	0.086	86
1282 ,1624	0.1	0.089	89
1399	0.1	0.087	87
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			

Table 9. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.			
Screen: Carbamate	UCL = 130		Sample Type: Surface Water
Analyte: Oxamyl	UWL = 119		Lab: CDFA
MDL: 0.05 ppb	LWL = 77		Chemist: S. Richman
	LCL = 66		
Sample Analyzed with Each Extraction Set	Spike Level	Results	Recovery
(Sample Number)	(ppb)	(ppb)	%
1330 ,1342	0.1	0.092	92
1130 ,1354	0.1	0.087	87
1360	0.1	0.087	87
1246 ,1516 , 1683	0.1	0.089	89
1540 ,1588 ,1685	0.1	0.086	86
1288,1546,1558, 1600	0.1	0.094	94
1202,1214,1226,1238,1258,1264,1324,1383,1389 ,1687, 1688	0.1	0.089	89
1196,1208,1220,1232,1294,1300,1318,1456,1462 ,1468, 1474, 1576	0.1	0.108	108
1528	0.1	0.097	97
1282 ,1624	0.1	0.097	97
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			

Table 1. Continuing quality control data (% recoveries) for the Spring 1991 San Joaquin River study.				
Screen: Endosulfan	UCL = 113		Sample Type: Surface Water	
Analyte: Endosulfan I	UWL = 106		Lab: CDFA	
MDL: 0.005 ppb	LWL = 76		Chemist: K. Hefner	
	LCL = 69			
Sample Analyzed with Each Extraction Set	Spike Level	Results	Recovery	
(Sample Number)	(ppb)	(ppb)	%	
3	0.010	0.007	70	
15	0.010	0.011	110	
9, 69, 23, 27	0.012	0.012	100	
1, 147, 159	0.012	0.010	83	
41, 154, 165	0.012	0.012	100	
33, 87, 123, 129, 171, 189, 273, 279	0.005	0.005	100	
40, 51, 57, 207, 213, 267	0.012	0.012	100	
81, 93, 105, 111, 177, 249, 495	0.012	0.010	83	
75	0.010	0.012	120*	
135, 219, 315, 543	0.010	0.009	90	
329, 395, 533, 539	0.010	0.010	98	
309, 321, 519, 441, 447, 513, 555	0.010	0.010	98	
423, 429, 549	0.010	0.009	86	
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.				
** Matrix spike recovery fell above the upper control limit.				

Table 2. Continuing quality control data (% recoveries) for the Spring 1991 San Joaquin River study.				
Screen: Endosulfan	UCL = 145		Sample Type: Surface Water	
Analyte: Endosulfan II	UWL = 131		Lab: CDFA	
MDL: 0.005 ppb	LWL = 75		Chemist: Karen Hefner	
	LCL = 60			
Sample Analyzed with Each Extraction Set	Spike Level	Results	Recovery	
(Sample Number)	(ppb)	(ppb)	%	
3	0.010	0.009	89	
15	0.010	0.011	110	
9, 69, 23, 27	0.012	0.013	108	
1, 147, 159	0.012	0.014	117	
41, 154, 165	0.012	0.013	108	
33, 87, 123, 129, 171, 189, 273, 279	0.005	0.005	100	
40, 51, 57, 207, 213, 267	0.012	0.011	92	
81, 93, 105, 111, 177, 249, 495	0.012	0.010	83	
75	0.010	0.011	110	
135, 219, 315, 543	0.010	0.011	110	
329, 395, 533, 539	0.010	0.012	120	
309, 321, 519, 441, 447, 513, 555	0.010	0.014	140	
423, 429, 549	0.010	0.011	110	
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.				

Table 3. Continuing quality control data (% recoveries) for the Spring 1991 San Joaquin River study.						
Screen: Endosulfan	UCL = 147		Sample Type: Surface Water			
Analyte: Endosulfan sulfate	UWL = 131		Lab: CDFA			
MDL: 0.005 ppb	LWL = 68		Chemist: Karen Hefner			
	LCL = 52					
Sample Analyzed with Each Extraction Set	Spike Level	Results	Recovery			
(Sample Number)	(ppb)	(ppb)	%			
3	0.010	0.010	95			
15	0.010	0.010	100			
9, 69, 23, 27	0.012	0.013	108			
1, 147, 159	0.012	0.016	133			
41, 154, 165	0.012	0.015	125			
33, 87, 123, 129, 171, 189, 273, 279	0.005	0.006	120			
40, 51, 57, 207, 213, 267	0.012	0.015	125			
81, 93, 105, 111, 177, 249, 495	0.012	0.014	117			
75	0.010	0.010	98			
135, 219, 315, 543	0.010	0.012	120			
329, 395, 533, 539	0.010	0.013	130			
309, 321, 519, 441, 447, 513, 555	0.010	0.011	110			
423, 429, 549	0.010	0.011	110			
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.						

Table 1. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.			
Screen: Endosulfan	UCL = 110	Sample Type: Surface Water	
Analyte: Diazinon	UWL = 105	Lab: CDFA	
MDL: 0.05 ppb	LWL = 85	Chemist: K. Hefner	
	LCL = 80		
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %
1331	0.10	0.11	110
1355	0.10	0.11	110
1343, 1361	0.10	0.10	100
1253	0.10	0.10	100
1247	0.10	0.09	90
1517	0.10	0.13	130**
1541	0.10	0.09	90
1547	0.10	0.09	90
1239,1265, 1289	0.10	0.09	90
1203,1215,1227,1259,1325,1384, 1390	0.10	0.09	90
1193,1221,1233,1295,1301,1319,1457,1463, 1469, 1475, 1577	0.10	0.10	100
1209, 1583	0.10	0.11	110
1529	0.10	0.10	100
1283	0.10	0.11	110
1625	0.10	0.10	100
1559, 1601	0.10	0.13	130**
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			
** Matrix spike recovery fell above the upper control limit.			

Table 2. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.			
Screen: Endosulfan	UCL = 120	Sample Type: Surface Water	
Analyte: Diazinon OA	UWL = 115	Lab: CDFA	
MDL: 0.05 ppb	LWL = 93	Chemist: K. Hefner	
	LCL = 88		
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %
1331	0.10	0.10	100
1355	0.10	0.12	120
1343, 1361	0.10	0.10	100
1253	0.10	0.10	100
1247	0.10	0.10	100
1517	0.10	0.09	90
1541	0.10	0.12	120
1547	0.10	0.11	110
1239,1265, 1289	0.10	0.10	100
1203,1215,1227,1259,1325,1384, 1390	0.10	0.10	100
1193,1221,1233,1295,1301,1319,1457,1463, 1469, 1475, 1577	0.10	0.10	100
1209, 1583	0.10	0.11	110
1529	0.10	0.11	110
1283	0.10	0.10	100
1625	0.10	0.11	110
1559, 1601	0.12	0.10	83
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			

Table 3. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.			
Screen: Endosulfan	UCL = 113		Sample Type: Surface Water
Analyte: Endosulfan I	UWL = 106		Lab: CDFA
MDL: 0.005 ppb	LWL = 76		Chemist: K. Hefner
	LCL = 69		
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %
1331	0.10	0.10	100
1355	0.10	0.11	110
1343 ,1361	0.10	0.10	100
1253	0.10	0.10	100
1247	0.10	0.08	80
1517	0.10	0.09	90
1541	0.10	0.10	100
1547	0.10	0.10	100
1559, 1601	0.10	0.10	100
1239, 1265, 1289	0.10	0.09	90
1203,1215,1227,1259,1325,1384, 1390	0.10	0.08	80
1193,1221,1233,1295,1301,1319,1457,1463, 1469, 1475, 1577	0.10	0.10	100
1209, 1583	0.10	0.10	100
1529	0.10	0.08	80
1283	0.10	0.11	110
1625	0.10	0.11	110
1398	2.00	1.74	87
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			

Table 4. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.			
Screen: Endosulfan	UCL = 145		Sample Type: Surface Water
Analyte: Endosulfan II	UWL = 131		Lab: CDFA
MDL: 0.005 ppb	LWL = 75		Chemist: K. Hefner
	LCL = 60		
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %
1331	0.10	0.12	120
1355	0.10	0.10	100
1343 ,1361	0.10	0.12	120
1253	0.10	0.12	120
1247	0.10	0.08	80
1517	0.10	0.09	90
1541	0.10	0.1	100
1547	0.10	0.11	110
1559, 1601	0.10	0.09	90
1239, 1265, 1289	0.10	0.1	100
1203,1215,1227,1259,1325,1384, 1390	0.10	0.11	110
1193,1221,1233,1295,1301,1319,1457,1463, 1469, 1475, 1577	0.10	0.11	110
1209, 1583	0.10	0.10	100
1529	0.10	0.09	90
1283	0.10	0.11	110
1625	0.10	0.11	110
1398	2.00	1.64	82
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			

Table 5. Continuing quality control data (% recoveries) for the Spring 1992 San Joaquin River study.			
Screen: Endosulfan	UCL = 147		Sample Type: Surface Water
Analyte: Endosulfan Sulfate	UWL = 131		Lab: CDFA
MDL: 0.005 ppb	LWL = 68		Chemist: K. Hefner
	LCL = 52		
Sample Analyzed with Each Extraction Set (Sample Number)	Spike Level (ppb)	Results (ppb)	Recovery %
1331	0.10	0.12	120
1355	0.10	0.13	130
1343 ,1361	0.10	0.09	90
1253	0.10	0.08	80
1247	0.10	0.13	130
1517	0.10	0.13	130
1541	0.10	0.11	110
1547	0.10	0.13	130
1559, 1601	0.10	0.11	110
1239, 1265, 1289	0.10	0.12	120
1203,1215,1227,1259,1325,1384, 1390	0.10	0.12	120
1193,1221,1233,1295,1301,1319,1457,1463, 1469, 1475, 1577	0.10	0.1	100
1209, 1583	0.10	0.09	90
1529	0.10	0.11	110
1283	0.10	0.09	90
1625	0.10	0.12	120
1398	2.00	2.08	104
UCL = upper control limit, UWL = upper warning limit, LWL = lower warning limit, LCL = lower control limit.			

APPENDIX II. BLIND SPIKE RESULTS

Appendix II. Blind Spike Results - Spring 1991 and 1992

Table 1. Blind Spike Data for the Spring (1991 and 1992) San Joaquin River Study.

Chemical	Spike Level (ppb)	Amount Found (ppb)	Recovery (%)	Date Analyzed
Organophosphate Screen				
Ethyl Parathion	0.05	0.060	120**	2/28/92
Chlorpyrifos	0.05	0.050	100	2/28/92
	0.06	0.050	83	3/26/92
Diazinon	0.05	0.060	120	2/28/92
	0.06	0.060	100	3/26/92
Methidathion	0.05	0.050	100	2/28/92
Malathion	0.06	0.060	100	3/26/92
Carbamate Screen				
Carbofuran	0.10	0.090	90	4/20/92
	0.10	0.090	90	4/20/92
Carbaryl	0.10	0.086	86	4/20/92
	0.10	0.086	86	4/20/92
Endosulfan Screen				
Diazinon	0.15	0.13	87	2/21/92

** Matrix spike recovery fell above the upper control limit set at 108%.

APPENDIX III. TEMPORAL VARIATION IN WATER QUALITY AND DISCHARGE MEASUREMENTS MADE IN THE SAN JOAQUIN RIVER AT LAIRD PARK

Appendix III. Temporal variation in water quality and discharge measurements made in the San Joaquin River at Laird Park (site 12) during the 1991 and 1992 spring seasons.

Date	Water Temp. (C°)	pH	DO[a] (mg/L)	EC[b] (µS/cm)	Total Ammonia (mg/L)	Discharge (ft^3/s)	TSS[c] (mg/L)	TOC[d] mg/L
03-04-91	14	7.4	8.7	1590	2	727	210	13
03-07-91	14	7.4	9.8	1500	NA[e]	857	130	17
03-11-91	14	7.8	8.4	1600	0.4	669	75	9.1
03-14-91	14	7.7	8.1	1630	0.6	637	75	<4.0
Rinse[f]							<0.3	<4.0
03-18-91	13	8.0	9.0	1690	0.6	717	93	10
03-21-91	13	7.6	7.8	1270	0.3	1390	180	9.7
03-25-91	14	7.6	7.6	1070	0.8	1570	460	18
03-28-91	13	7.5	8.7	542	0.8	2350	200	16
Rinse							1.2	<4.0
04-01-91	17	7.8	7.2	1200	0.6	1310	160	13
04-04-91[g]	18	8.0	7.6	1690	0.6	961	120	11
04-08-91	16	7.9	8.7	1980	0.4	870	120	17
04-11-91	14	7.9	9.8	2110	0.2	688	90	7.0
04-15-91	18	8.0	9.4	2470	0.2	567	88	8.1
04-18-91	17	7.9	10	2150	0.9	466	96	16

Appendix III. Temporal variation in water quality and discharge measurements made in the San Joaquin River at Laird Park (site 12) during the 1991 and 1992 spring seasons.

Date	Water Temp. (C°)	pH	DO[a] (mg/L)	EC[b] (µS/cm)	Total Ammonia (mg/L)	Discharge (ft^3/s)	TSS[c] (mg/L)	TOC[d] mg/L
04-22-91	19	7.7	10	1750	0.4	566	96	17
04-25-91[g]	18	7.7	8.3	1610	0.4	547	76	14
03-02-92	16	8.1	7.9	1700	0.8	744	110	15
03-05-92	14	7.6	8.4	1610	0.4	730	96	11
03-09-92	15	7.8	7.5	1370	0.4	975	140	6.2
Rinse							<1.0	<4.0
03-12-92	16	7.8	8.4	1520	0.6	794	89	<4.0
03-16-92	16	7.4	9.0	1630	0.3	714	74	<4.0
03-19-92	16	7.5	9.8	1700	0.8	727	80	<4.0
03-23-92	17	7.4	8.5	1680	0.5	891	110	<4.0
03-26-92	18	7.7	7.5	1460	0.6	961	110	<4.0
03-30-92	18	7.7	7.6	1760	0.8	926	93	4.8
04-02-92	19	7.8	8.4	1760	0.4	892	94	<4.0
04-06-92	19	7.9	8.8	1910	0.6	672	68	<4.0
04-09-92	19	8.1	8.8	1410	0.3	638	84	9.2
04-13-92	19	7.6	7.8	2040	0.7	649	66	10

Appendix III. Temporal variation in water quality and discharge measurements made in the San Joaquin River at Laird Park (site 12) during the 1991 and 1992 spring seasons.

Date	Water Temp. (C°)	pH	DO[a] (mg/L)	EC[b] (µS/cm)	Total Ammonia (mg/L)	Discharge (ft^3/s)	TSS[c] (mg/L)	TOC[d] mg/L
04-16-92[g]	21	8.0	9.9	1780	0.8	505	66	8.4
4-20-92	18	7.6	7.8	1860	0.5	500	66	9.1
04-23-92	17	7.5	9.0	1810	0.3	466	72	9.2
04-27-92	22	8.0	12	1850	0.3	406	62	4.1
04-30-92	20	7.7	8.7	1970	0.3	375	88	6.3
05-04-92	20	8.3	11	2000	0.3	346	81	7.1

a. DO = dissolved oxygen.
b. EC = electrical conductivity, at 25°C, in microsiemens per centimeter (µS/cm).
c. TSS = total suspended sediment. Method detection limit = 0.3 mg/L.
d. TOC = total organic carbon. Method detection limit = 1.0 mg/L.
e. NA = not available.
f. Equipment rinse samples were analyzed to determine if cross contamination occurred between samples.
g. Indicates Lagrangian sample.

APPENDIX IV. WATER QUALITY AND DISCHARGE MEASUREMENTS MADE DURING THE LAGRANGIAN SURVEYS

Appendix IV. Water quality and discharge measurements made during the Lagrangian surveys conducted during the 1991 and 1992 spring seasons.

Date	Site	Hour	Water Temp. (C°)	pH	DO[a] (mg/L)	EC[b] (µS/cm)	Total Ammonia (mg/L)	Discharge (ft^3/s)	TSS[c] (mg/L)	TOC[d] (mg/L)
04-02-91	1	1015	18	7.9	7.2	463	0.2	60	48	10
04-02-91	2	0815	16	7.7	8.0	2760	<0.1	265	160	8.7
04-02-91	18	2000	18	7.7	8.6	2480	<0.1	402	110	10
04-02-91	3	0915	15	8.0	7.3	3310	0.2	23	36	15
04-02-91	4	1600	19	7.9	7.8	2410	0.4	51	50	20
04-02-91	5	2300	16	7.4	5.6	990	1	10	71	9.2
04-03-91	6	0200	16	7.4	8.0	142	0.2	256	42	<4.0
04-03-91	7	0300	16	7.7	7.8	1700	0.4	838	88	7.4
04-03-91	Rinse[e]								1.0	4.5
04-03-91	8	1145	No water in Orestimba Creek at time of sampling.							
04-03-91	9	1830	24	7.5	4.7	1040	>10	22	48	20
04-03-91	Rinse								7.3	<4.0
04-03-91	10	2300	18	7.8	7.0	1500	0.1	910	110	11
04-04-91	11	0145	17	8.7	8.8	1330	0.2	1.37	39	5.4
04-04-91	12	0930	18	8.0	7.6	1690	0.6	961	120	11
04-04-91	13	0530	17	7.5	7.7	254	0.2	245	37	<4.0
04-04-91	14	1330	16	7.9	6.9	2200	0.3	0.21	46	13

Appendix IV. Water quality and discharge measurements made during the Lagrangian surveys conducted during the 1991 and 1992 spring seasons.

Date	Site	Hour	Water Temp. (C°)	pH	DO[a] (mg/L)	EC[b] (µS/cm)	Total Ammonia (mg/L)	Discharge (ft^3/s)	TSS[c] (mg/L)	TOC[d] (mg/L)
04-04-91	Rinse								0.8	<4.0
04-04-91	15	1930	20	7.9	8.2	1300	<0.1	1290	120	7.1
04-04-91	16	1615	20	7.6	7.8	153	0.1	199	20	<4.0
04-04-91	17	2300	19	7.9	7.4	1240	<0.1	1525	100	7.9
04-23-91	1	1530	24	8.6	>12	2010	0.3	3[f]	24	16
04-23-91	2	1145	18	7.8	8.2	2280	0.6	198	130	16
04-23-91	18	0215	18	8.0	7.7	2470	0.3	223	120	16
04-23-91	3	1415	22	8.3	>12	4200	0.6	26	80	26
04-23-91	4	2245	18	8.3	7.4	3210	0.2	3.08	99	32
04-24-91	5	0345	18	7.4	4.0	1020	2	8.22	68	16
04-24-91	6	1045	18	7.4	8.8	219	0.2	168	54	NA
04-24-91	7	1120	19	8.0	9.3	1700	0.2	462	110	14
04-24-91	8	2030	17	8.2	10	826	0.9	5.58	380	NA
04-24-91	Rinse								2.3	4.8
04-25-91	9	0500	15	7.4	7.1	593	3	40	69	17
04-25-91	10	1000	16	8.1	8.1	1610	0.3	514	81	16

Appendix IV. Water quality and discharge measurements made during the Lagrangian surveys conducted during the 1991 and 1992 spring seasons.										
Date	Site	Hour	Water Temp. (C°)	pH	DO[a] (mg/L)	EC[b] (µS/cm)	Total Ammonia (mg/L)	Discharge (ft^3/s)	TSS[c] (mg/L)	TOC[d] (mg/L)
04-25-91	11	1500	17	8.3	11	1530	0.3	8.02	170	13
04-25-91	Rinse								1.3	6.5
04-25-91	12	2315	18	7.7	8.3	1610	0.4	547	76	14
04-25-91	13	2115	17	7.0	8.8	83	0.1	666	45	6.6
04-26-91	14	0445	15	7.9	8.6	1570	1	20	780	22
04-26-91	15	0915	16	7.2	8.7	761	0.1	912	130	9.9
04-26-91	16	0445	16	7.7	8.7	133	0.1	264	32	<4.0
04-26-91	17	1345	18	7.9	9.4	727	0.3	1140	110	11
04-26-91	Rinse								1.5	<4.0
04-14-92	1	1400	21	8.1	7.0	2090	0.2	24	14	4.4
04-14-92	2	1015	18	7.7	7.4	2500	0.4	191	92	9.0
04-14-92	18	2300	20	7.9	8.4	2640	0.3	258	54	8.6
04-14-92	3	1145	19	8.1	9.1	3490	0.4	15	28	18
04-14-92	4	1900	24	7.2	4.1	2410	0.8	5.2	22	<4.0
04-15-92	5	0430	18	7.3	3.4	1210	2	7.9	50	<4.0
04-15-92	6	0645	18	6.7	7.2	148	0.2	175	20	<4.0

Appendix IV. Water quality and discharge measurements made during the Lagrangian surveys conducted during the 1991 and 1992 spring seasons.

Date	Site	Hour	Water Temp. (C°)	pH	DO[a] (mg/L)	EC[b] (µS/cm)	Total Ammonia (mg/L)	Discharge (ft^3/s)	TSS[c] (mg/L)	TOC[d] (mg/L)
04-15-92	Rinse								<0.3	<4.0
04-15-92	7	0745	19	8.2	7.3	1800	0.4	461	60	<4.0
04-15-92	8	1520	20	8.3	9.3	955	0.7	7.3	110	<4.0
04-15-92	9	2230	20	7.7	5.8	568	4	22	94	300
04-16-92	10	0300	19	7.5	7.6	1840	0.6	518	68	<4.0
04-16-92	11	0745	16	8.0	9.1	1600	0.3	18	220	<4.0
04-16-92	12	1430	21	8.0	9.9	1780	0.8	505	66	8.4
04-16-92	Rinse								<0.3	<4.0
04-16-92	13	1200	20	7.9	8.2	231	0.2	216	16	<4.0
04-16-92	14	1945	23	8.5	11	1840	0.3	13	96	11
04-16-92	15	2330	22	7.5	8.2	1330	0.6	640	67	6.6
04-16-92	16	1830	19	7.5	9.0	94	0.2	795	10	5.3
04-17-92	17	0330	19	7.5	8.6	618	0.2	1350	42	<4.0

a. DO = dissolved oxygen.
b. EC = electrical conductivity measured in microsiemens per centimeter at 25°C.
c. TSS = total suspended sediment.
d. TOC = total organic carbon.
e. Equipment rinse samples were analyzed to determine if cross contamination occurred between sampling sites.
f. Discharge estimated.
g. NA = not available.